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TM 9-9618

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

RADAR TEST EQUIPMENT

MODEL TS-295/UP

DEPARTMENT OF THE ARMY • APRIL 1952

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DESTRUCTION OF ABANDONED MATERIEL IN THE COMBAT ZONE

In case it should become necessary to prevent the capture of this equipment, and when ordered to do so,

DESTROY IT SO THAT NO PART OF IT CAN BE SALVAGED, RECOGNIZED OR USED BY THE ENEMY. BURN ALL PAPERS AND BOOKS.

MEANS

1. Explosives, when provided.
2. Hammers, axes, sledges, machetes, or whatever heavy objects are readily available.
3. Burning by means of incendiaries such as gasoline, oil, paper or wood.
4. Grenades and shots from available arms.
5. Burying all debris, or disposing of it in streams or other bodies of water, where possible, and when time permits.

PROCEDURE

1. Obliterate all identifying marks. Destroy nameplates and circuit labels.
2. Demolish all panels, castings, switch and instrument boards.
3. Destroy all controls, switches, relays, connections and meters.
4. Rip out all wiring and cut interconnections of electrical equipment. Smash gas, oil and water-cooling systems in gas-engine generators, etc.
5. Smash every electrical or mechanical part, whether rotating, moving or fixed.
6. Break up all operating instruments such as keys, phones, microphones, etc.
7. Destroy all classes of carrying cases, straps, containers, etc.
8. Bury or scatter all debris.

DESTROY EVERYTHING

SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of Bureau of Ships Manual or superseding instructions on the subject of Radio-Safety precautions to be observed.

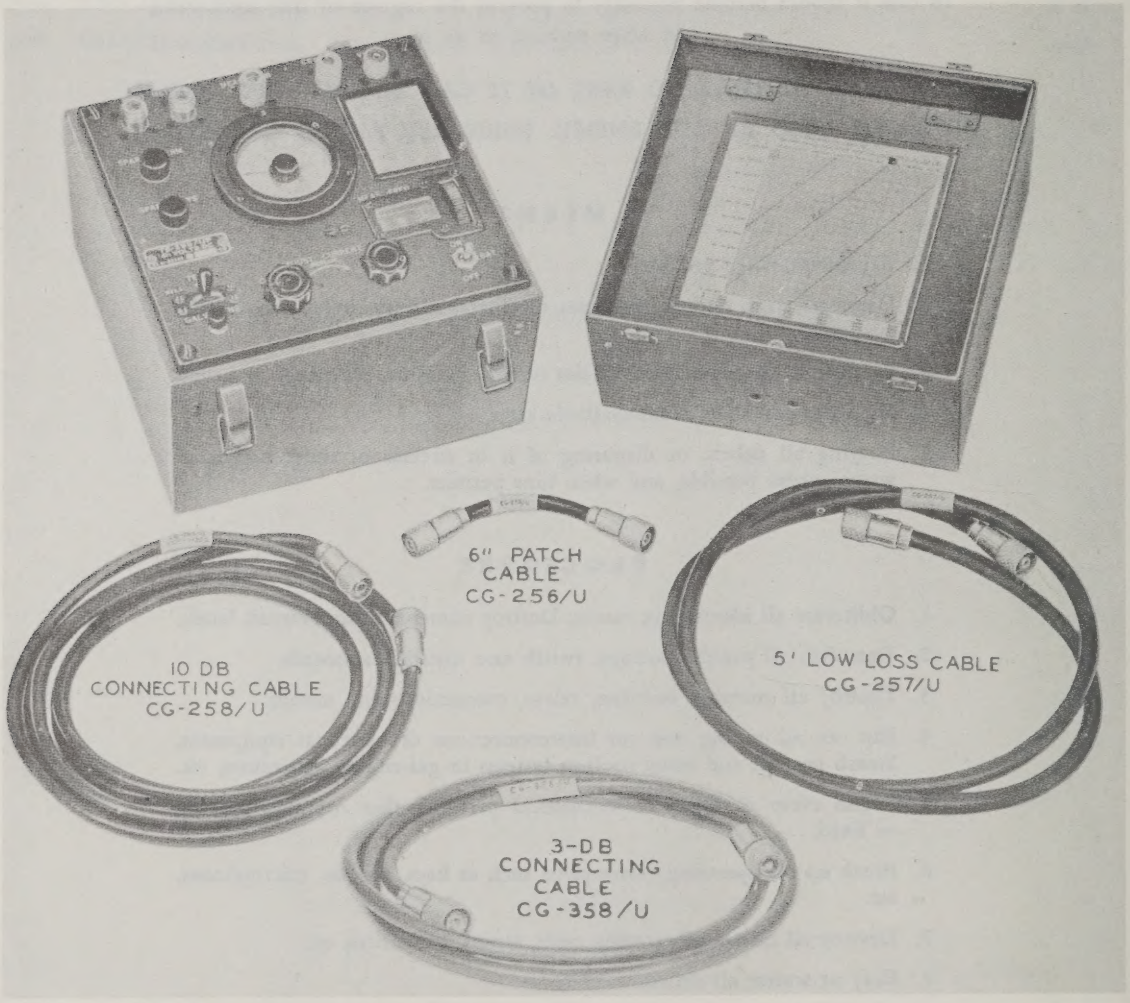

Figure 1-1. Radar Test Equipment Model TS-295/UP

SECTION I

GENERAL DESCRIPTION

1. BRIEF DESCRIPTION.

a. Radar Test Equipment Model TS-295/UP is a portable equipment employed in maintaining radar systems operating in the SW1 and SW2 range. While designed for use with SV equipment, it will also serve other systems operating in the SW frequency range. It can measure average powers from 0.5 to approximately 12.5 mw (milliwatts) which can be extended to the range 5 to 125 mw by using the 10-db connecting cable and to 250 mw by using the 10-db and 3-db connecting cables.

b. The components of the measuring set are shown in Figure 1-1. The four connecting cables are carried in the cover as shown in Figure 1-2. All operating controls are located on the panel shown in Figure 1-3. A spare thermistor and spare crystal are mounted in containers on the panel. The measuring set with cover on, is shown in Figure 1-4.

2. REFERENCE DATA.

The following reference data applies:

a. Nomenclature—Radar Test Equipment Model TS-295/UP.

b. Contract No. NXsr-66745. 16 June 1944.

c. Contractor—Western Electric Co., New York, N. Y.

d. Cognizant Naval Inspector—Inspector of Naval Material, New York, N. Y.

e. Number of packages involved per complete shipment—one Radar Test Equipment Model TS-295/UP.

f. Total cubical contents—crated 2.1 cu. ft.; uncrated—.57 cu. ft.

g. Total weight—crated 16 lbs.; uncrated 12 lbs.

h. Power Source—three flashlight dry cells CNC-19031.

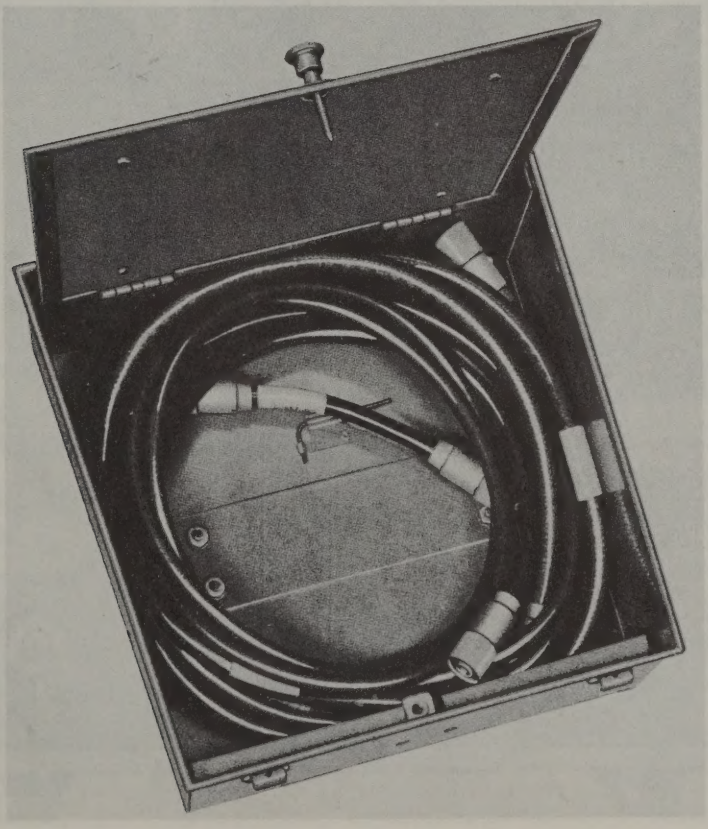

Figure 1-2. Radar Test Equipment Model TS-295/UP Cover and Cables

i. Frequency Range—entire SW band (SW1 and SW2).

j. Input power range—0.5 to approximately 12.5 milliwatts (—3 to +11 dbm) at 75°F. Extended by 10-db and 3-db connecting cables.

k. Impedance—All r-f connectors are 50-ohm, type N. For calibration of cables see Section 6, paragraph 2.

l. D-C meter range—0-1.5 milliamperes, also calibrated in milliwatts.

m. Accuracy of measurement.

Frequency ± 2 megacycles (relative)

Power ± 1 db (For TS-295/UP only.)

This limit does not apply to overall measurements of radar equipments. The accuracy of these measurements will depend on how well the coupling losses through the directional coupler, loss between radar and test antennas and connecting cable loss are known.

n. Temperature range: —7C (20F) to +50C (+122F).

3. COMPONENT PARTS.

Equipment Supplied

Quantity	*Name of Unit*	*Over-all Dimensions*	*Weight Lbs.*
1	Radar Test Equipment TS-295/UP (Uncrated)	9¼ in. x 9⅜ in. x 11⅜ in.	12
	(Crated)	14⅜ in. x 14⅝ in. x 16⅞ in.	16

Auxiliary equipment located in cover of box:

10-db connecting cable, CG-258/U

5-ft. low-loss cable, CG-257/U

6-in. patch cable, CG-256/U

3-db connecting cable, CG-358/U

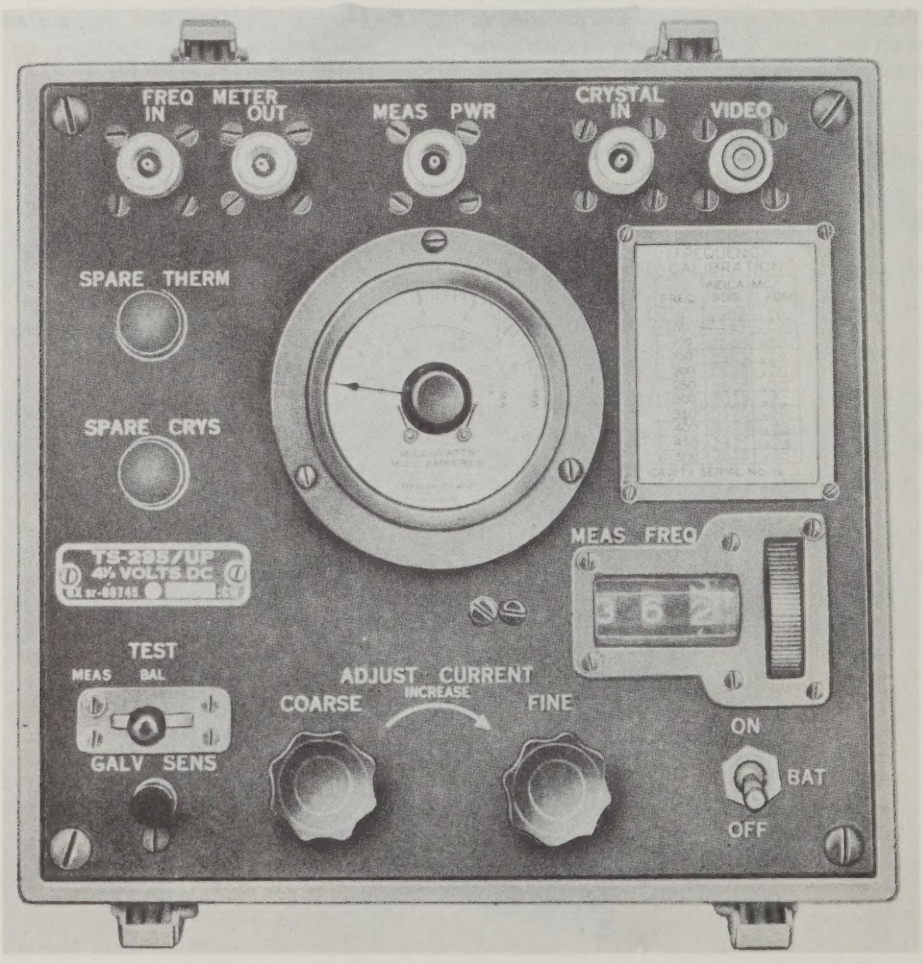

Figure 1-3. Radar Test Equipment Model TS-295/UP Panel View

Figure 1-4. Radar Test Equipment Model TS-295/UP With Cover On

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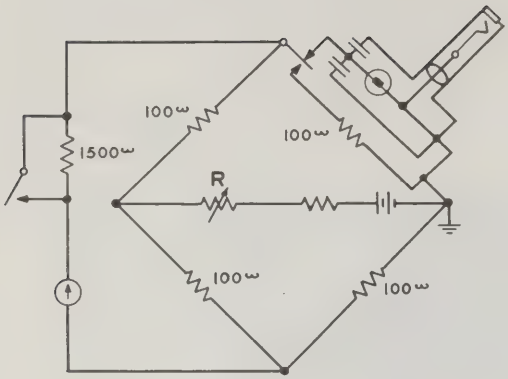
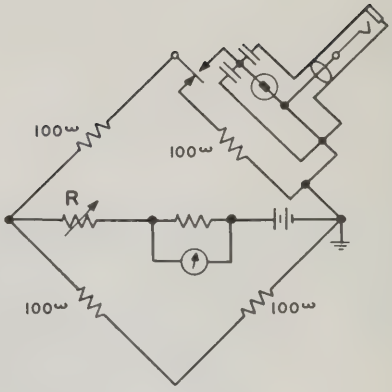
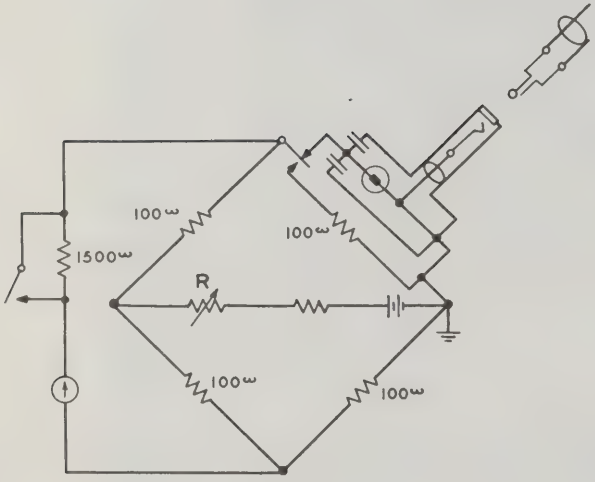


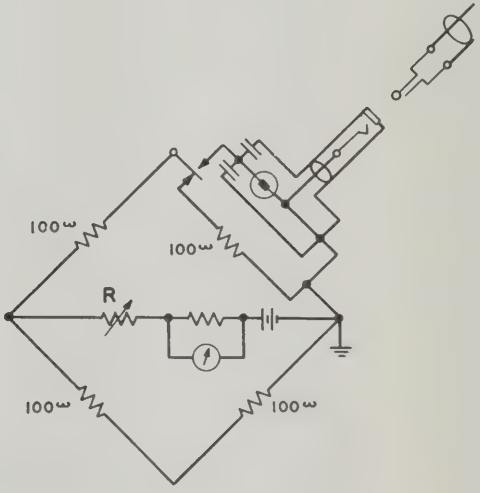
1. NO R.F. CONNECTED.
"TEST" KEY ON "BAL" POSITION.
BALANCE BRIDGE BY ADJUSTING
(R) UNTIL METER READS ZERO



2. NO R.F. CONNECTED.
"TEST" KEY ON "MEAS" POSITION.
METER READING IS CURRENT IN
EACH BRIDGE ARM.
DESIGNATE AS READING NO. 1



3. R.F. CONNECTED.
"TEST" KEY ON "BAL" POSITION.
BALANCE BRIDGE BY ADJUSTING
(R) UNTIL METER READS ZERO.



4. R.F. CONNECTED.
"TEST" KEY ON "MEAS" POSITION.
METER READING IS CURRENT IN
EACH BRIDGE ARM.
DESIGNATE AS READING NO. 2

Figure 2-1. Power Measurement Diagrams

SECTION II

THEORY OF OPERATION

1. GENERAL.

The electrical circuit is composed of a Wheatstone bridge circuit, a frequency meter, and a crystal detector. In one arm of the Wheatstone bridge is a radio-frequency chamber containing a thermistor which can be used to measure either CW or pulsed power. In the latter case, the reading will be the power averaged over the cycle. The frequency meter consists of a tunable coaxial cavity coupled by a loop across the through-transmission line. The crystal detector provides a video output for oscilloscope observation of the rectifier pulse.

2. POWER-MEASURING CIRCUIT.

a. The heart of the power-measuring circuit is the thermistor, a small semi-conducting bead whose d-c resistance will change rapidly as the power dissipated in it changes. Thus, to maintain a constant resistance, for a given ambient temperature, a constant power will be required. This power may be either radio-frequency (r-f), d-c, or a combination of the two. The process of determining the r-f power consists of first measuring the d-c power required to maintain the thermistor resistance at a value of 100 ohms when there is no r-f input, and then measuring the d-c power required after the r-f is applied. The r-f power can be computed from the difference between the d-c powers. Pulse signals from a radar transmitter may be measured in the same manner as CW power, but the duty cycle of the transmitter must be taken into account to obtain peak power. Basically, the result of any power measurement made with the set is average power, i.e., it is the value of an equivalent d-c power having the same heating effect as the power being measured. The heating effect of pulse signals depends upon the duration of each pulse, the number of pulses per second, the peak power of each pulse, and the pulse shape. Because of the high ratio of idle time to pulse time in the duty cycles of radar transmitters, the average power determined by measurement with the power meter will be much smaller than the peak power of the pulses.

b. The d-c path through the thermistor is made a part of a Wheatstone bridge circuit, the other arms of which are resistances of 100 ohms. If the voltage impressed across the bridge by the battery supply is varied until the bridge is balanced, as indicated by the zero reading of the meter across the other arms of the bridge, the resistance of the thermistor will also be 100 ohms.

c. The details of the power-measuring circuit are shown in Figure 7-5 and in a more simplified fashion in Figure 2-1.

Figure 2-1 shows the fundamental circuits established in the course of making a power measurement. Referring to that figure, in diagram 1, the meter is connected across the bridge as a galvanometer and the adjusting resistance R is changed until the thermistor resistance is driven down to 100 ohms, which balances the bridge. In diagram 2, the TEST key is shown in the MEAS position. A 100-ohm resistance is substituted for the thermistor. This substitution does not disturb the bridge balance. In this operation, the meter is bridged across a small resistance in the battery supply circuit. The value of this resistance is so chosen that the meter reads one-twentieth the actual current flowing in the battery supply circuit. When the bridge is balanced the current through the thermistor, or the 100-ohm resistance that is substituted for it, equals one-half the battery supply current and, therefore, the meter reads one-tenth the current through the thermistor or the 100-ohm resistance. The meter is calibrated in mw corresponding to the power dissipated by the thermistor when the bridge is balanced. Each of the above operations is repeated in diagrams 3 and 4 with the r-f input connected. A new bridge balance is established and a new value of d-c current is read. Since the resistance of the thermistor is the same as before, the total power dissipated must be the same. The 100-ohm resistance is substituted for the thermistor when the bridge circuit is in the MEAS condition, to provide circuit conditions that will allow the test set to be used for adjusting the power output of a source, such as a signal generator, to a predetermined value.

d. The detailed calculation of power measured by the thermistor is as follows. Let the measured d-c current with no r-f input be I_1 and the d-c power P_1

$$P_1 = I_1^2 \times 100$$

With r-f input, let P_2 = the d-c power in the thermistor, and I_2 = d-c current

$$P_2 = I_2^2 \times 100$$

With an r-f input, the total power remains the same but is made up partly of r-f and partly of d-c.

Therefore,

$$P_1 = P_2 + (\text{r-f power})$$

or

$$(\text{r-f power}) = P_1 - P_2$$

$$= (I_1^2 \times 100) - (I_2^2 \times 100) = (I_1^2 - I_2^2)\ 100$$

To facilitate these computations, the meter scale has been calibrated in milliwatts equivalent to the power dissipated by the d-c current through a 100-ohm resistance. Thus, the reading on the milliwatt scale is

the d-c power dissipated in the thermistor when its resistance is 100 ohms, and the difference between Reading No. 1 and Reading No. 2 is the r-f power. Reading No. 1 indicates the maximum r-f power that can be measured without the use of an attenuator.

e. A slightly different procedure and computation are required when adjusting an r-f power to a given value, such as adjusting the output of a signal generator to six mw. In this case the r-f power value is known before the measurement is started and need not be computed; P_1 is determined in the usual manner; and P_2 becomes the unknown. P_2 is readily determined by subtracting the desired r-f power from P_1. If the thermistor were left in the circuit, a cut-and-try procedure would be required to obtain P_2 and the desired r-f power to add up to P_1. To eliminate this cut-and-try procedure, a 100-ohm resistor is substituted for the thermistor when the TEST key is in the MEAS position. In the MEAS position, the controls can be adjusted to give the desired P_2 in the substituted 100 ohms. Then, when the thermistor is restored, it is only necessary to adjust the r-f power until the bridge is balanced. Under this condition the thermistor is 100 ohms and the power dissipated in the thermistor is P_2 + the desired r-f power.

f. In balancing the bridge initially with d-c only, it will be noticed that the meter pointer first rises and then falls. The reason for this is that the resistance of the thermistor at first decreases more slowly than the current through the bridge increases. As the meter peak is reached, the resistance of the thermistor begins to decrease at a greater rate, and from this point the thermistor rapidly approaches 100 ohms, which balances the bridge and causes the meter reading to decrease to zero.

g. The thermistor is contained in a specially designed radio-frequency chamber which is shown in Figure 2-2. This assembly consists essentially of a coaxial line short-circuited to radio frequencies at each end, with the thermistor incorporated in the central conductor and an input jack for connecting the r-f power. The thermistor is held in the central conductor by a split chuck arrangement which does not require soldering. The dimensions of this chamber and the location of the thermistor within it are so chosen that when the d-c resistance of the thermistor is 100 ohms, the high-frequency impedance at the input jack, which is designated MEAS PWR, is very nearly 50 ohms with only a small impedance angle. At the round end of the chamber the d-c path is open, but an a-c short-circuit path is produced by the small condensers (polystyrene washers as dielectric). This prevents the d-c path through the thermistor from being short-circuited by the r-f chamber.

3. FREQUENCY METER.

a. The frequency meter is a tunable coaxial cavity type. Coupling is made to the coaxial cavity by means of a loop bridged across the transmission line. The structure consists of a cylindrical chamber and a sliding central conductor whose length projecting into the chamber can be changed by the operation of a knurled knob. A counter dial indicates the relative length projecting into the chamber. In effect, this structure is a coaxial line of adjustable length. When adjusted to resonance at the applied frequency (about ¾ wavelength long) it produces a large reflection in the transmission line which results in the transmission of minimum power. The two ends of the transmission line terminate on the panel in jacks designated FREQ METER IN and FREQ METER OUT. The frequency to be measured is connected to the input of this line and the thermistor circuit to the other end. With the frequency meter off tuning, there will be a given power input to the thermistor circuit. Under this condition, the bridge is adjusted for balance so as to give a zero reading on the meter. The frequency meter is then adjusted by means of the MEAS FREQ knob, and when the cavity is in resonance with the input frequency, the power delivered to the thermistor is decreased. Decreasing the power causes the bridge to become unbalanced because of the change in the thermistor resistance, and the meter will deflect upward. The deflection will be a maximum when the frequency meter is in tune. From the setting of the FREQ METER indicator the applied frequency can be determined from the calibration charts as described in Section IV, paragraph 7.

b. Frequency measurements can also be made using the crystal. The output of the crystal detector circuit will vary directly with the power. For this reason, when making frequency measurements, a minimum indication is obtained at resonance as compared with maximum indication when using the thermistor circuit. When making frequency measurements of pulsed signals, the frequency meter is tuned for minimum amplitude at the center of the pulse image as viewed on the oscilloscope connected to the output of the crystal detector.

4. CRYSTAL.

a. The crystal is provided to serve as a rectifier of pulsed power using an oscilloscope to view the pulses. Viewing of pulses requires a type of oscilloscope which is either self-triggering or which is synchronized with the transmitter sending out the pulsed power. It should be pointed out in this connection that the peak power impressed upon the crystal should not exceed 1 watt (+30 dbm). For this reason, always connect the 10-db connecting cable to the reflected power output jack of a directional coupler when using the crystal. No output control is provided, it being assumed that such a control is included in the oscilloscope itself. For use on radar systems having a unidirectional coupler, i.e., a coupler having only one output jack, connection may be made by inserting an additional 20 to 30 db loss cable between the TS-295/UP crystal detector and the coupler.

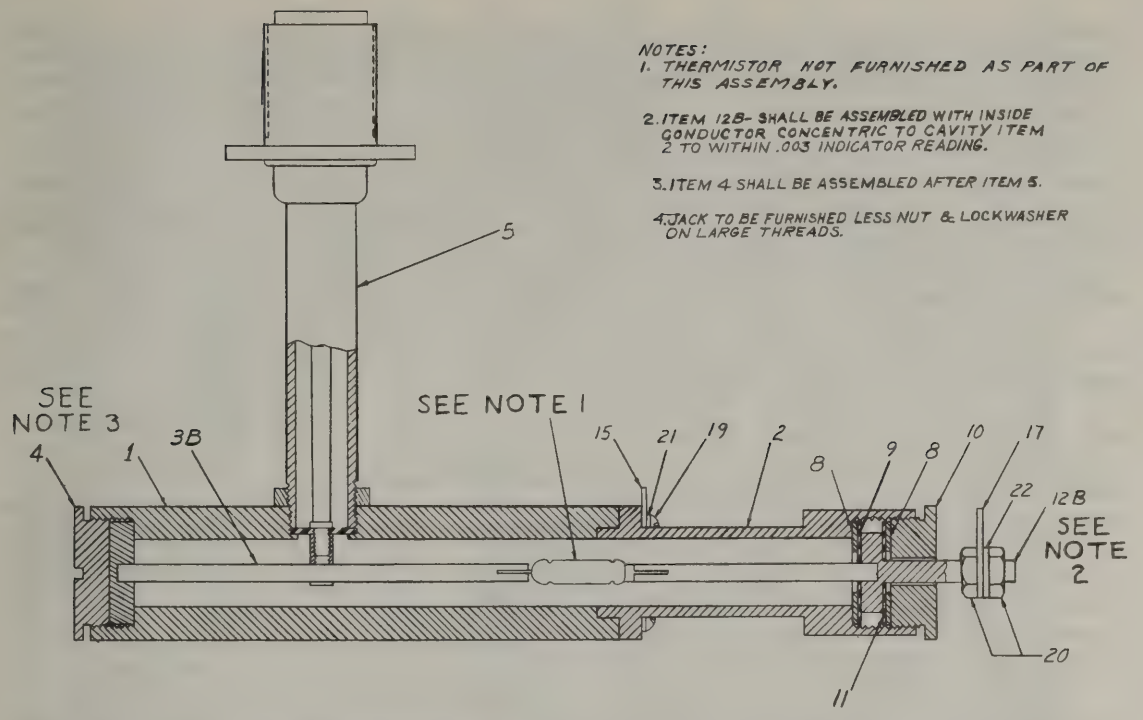


Figure 2-2. Radar Test Equipment Model TS-295/UP Radio-Frequency Chamber Assembly

5. CONNECTING CABLES.

a. The 10-db connecting cable CG-258/U is comprised of approximately 11 feet of 50-ohm coaxial cable whose length has been adjusted to 10 ± 0.5 db at midband (200). The central conductor is high-resistance wire and a low-loss dielectric is used. The result is a cable of low-temperature coefficient and, therefore, temperature changes may be disregarded. The frequency characteristic of the cable is shown in Figure 4-2.

b. The nominal loss of the 5-foot loss cable CG-257/U is one db. It is used when the power is too low to measure accurately with the 10-db cable in the circuit, as when the radar is in trouble or when measuring very low values of reflected power.

c. The 6-inch patch cable CG-256/U is used for patching between FREQ METER and MEAS PWR jacks on the measuring set.

d. All of the above cables have plug connections. In addition, a 3-db connecting cable CG-258/U with a plug on one end and a jack on the other end is provided to extend the range of the 10-db cable when measuring high powers.

SECTION III
INSTALLATION AND ADJUSTMENT

1. PROCEDURE.

a. Operate the set with the panel in the horizontal position. All adjustments and cable connections are given in Section IV—Operation. When the set is not in use, turn BAT switch to OFF and place the cover on the set.

b. As a check to see that the meter is in working condition perform the following:

(1) Measure the power of an r-f source as described in Section IV, paragraph 1.

(2) Measure the frequency of an r-f source as described in Section IV, paragraph 5.

(3) Rectify an r-f pulse and display it on an oscilloscope as described in Section IV, paragraph 6.

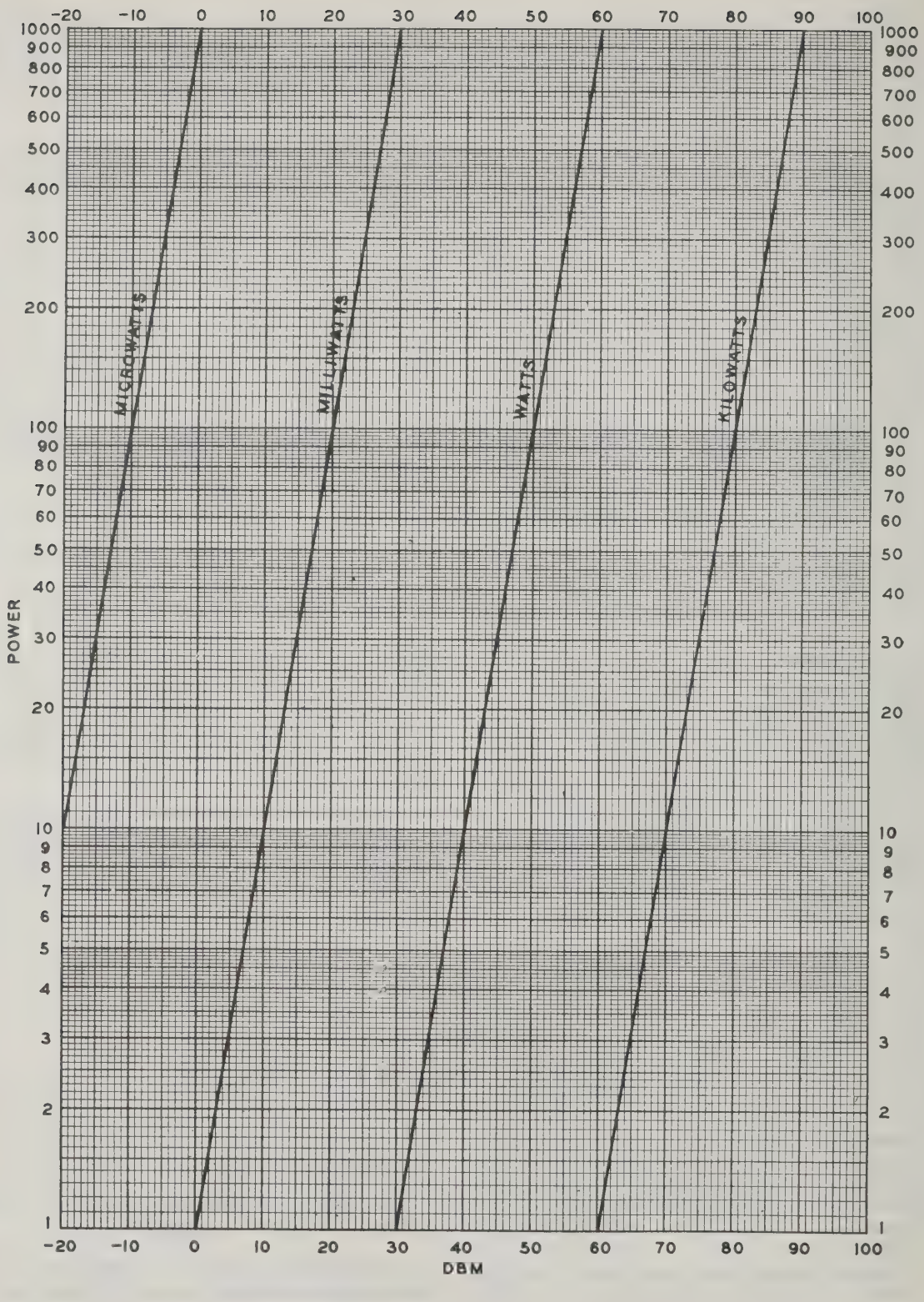


Figure 4-1. Relation of Power and dbm

SECTION IV
OPERATION

1. MEASUREMENT OF POWER - GENERAL.

a. MEASURING PROCEDURE.

(1) Turn the ADJUST CURRENT knobs COARSE and FINE as far as they will go in a counterclockwise direction. In this position a minimum current will be flowing through the thermistor. Do not connect r-f power yet.

(2) Operate the BAT switch to ON.

(3) With the TEST key in its normal position, BAL, adjust the COARSE and FINE knobs until a bridge balance is obtained, as indicated by a zero reading on the meter. In making this adjustment, the first movement of the meter will be an increase up to a reading of about 3 to 10 mw after which the reading will decrease as the COARSE knob is turned farther. Care should be taken that the adjustment is made to zero and not appreciably lower, since the meter will read in a reverse direction as far as the stop if the resistance of the thermistor is reduced too far. A final adjustment of the balance should be made with the GALV SENS key depressed, but this should not be done when the meter reading exceeds 0.5 mw or is less than zero.

(4) When a balance is obtained, operate the TEST key to the MEAS position, and read the meter in milliwatts. Designate this as Reading No. 1.

(5) Turn the ADJUST CURRENT knobs COARSE and FINE as far as they will go in a counterclockwise direction.

(6) Connect the r-f power source to be measured through the 10-db cable to the MEAS PWR jack.

CAUTION

In order to protect the thermistor and crystal from damage, always connect an unknown power through the 10-db connecting cable CG-258/U to the proper jack, unless it is certain that the average power is below +11 dbm when using the thermistor or that the peak power is below +30 dbm when using the crystal. If measuring an unknown power which may be more than 10-db greater than these values, make the connection through the 10-db cable CG-258/U and 3-db cable CG-358/U in series.

(7) Repeat operation in step (3) above for the new condition.

Note

If meter reading cannot be brought up to zero, the power is too great to measure.

(8) When a bridge balance is obtained, operate the TEST key to the MEAS position and again read the meter in milliwatts. Designate this as Reading No. 2.

(9) The r-f power in milliwatts at the MEAS PWR jack is Reading No. 1 minus Reading No. 2. To obtain the r-f power in milliwatts at the input to the connecting cable, multiply the milliwatt reading by 10.

(10) If it is required to have power in dbm, convert the milliwatts measured above Reading No. 1 —Reading No. 2) to dbm. (See Figure 4-1.) Dbm is the power level with respect to one mw, e.g., + 8 dbm is 8 db above one mw, —3 dbm is 3 db below one mw.

(11) If measurements are made at the upper or lower frequency end of the band, it may be desirable to take into account the frequency characteristic of the connecting cable. See Figure 4-2 for this characteristic.

2. MEASUREMENT OF RADAR POWER OUTPUT.

a. GENERAL.

(1) Keep a permanent record of the performance of every radar installation showing the results of each test. Such a record will serve as a life history of the installation and will show up any progressive deterioration in performance. It will be a useful guide in locating defective apparatus or improper adjustments. The results of the initial test can be compared with the rated power output or with a record of the results obtained with a radar system of the same design which is known to be in good condition. Day-to-day power checks should be made regularly.

(2) Low power output means trouble with the transmitter or transmitter line. Gradual decreases in power output shown by day-to-day test results may indicate deterioration of the magnetron or vacuum tubes. A radical change from the last measurement may indicate complete failure of a tube or other pieces of apparatus, damaged wiring, or an obstruction or loose connection in the transmission line. Inspection of the equipment often will give simple indications of the location of the trouble, such as sparking at protective gaps, overheated or cold tubes, broken wires, loose transmission line connections, etc. If the trouble is not readily located, Maintenance Personnel should refer to the Radar Instruction Book.

(3) The accuracy of TS-295/UP alone is within ± 1 db. If allowable inaccuracies in the calibration of the directional coupler and the two calibrated connecting cables were maximum and in the same direction, the cumulative error for the complete measuring

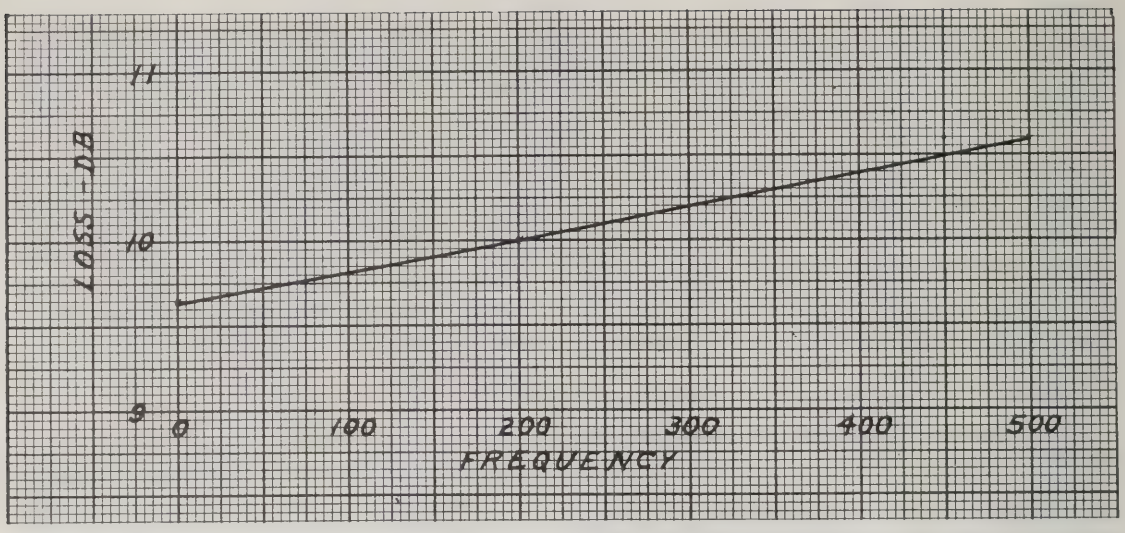


Figure 4-2. Radar Test Equipment Model TS-295/UP Loss-Frequency Characteristic of 10 db Connecting Cable

set and connections could be as much as 2.5 db, but ordinarily will be much less.

b. RADAR TEST CONNECTIONS.

(1) DIRECTIONAL COUPLER.—Connect from the direct power output jack of the directional coupler to the test set by means of the 10-db connecting cable CG-258/U. In some cases it may be necessary to use the 10-db and 3-db cables in series to bring the power within the range of the meter. (Where directional couplers have but one output jack, it is almost invariably used for measuring direct power.)

c. MEASUREMENT OF POWER OF TRANSMITTER.—Measure the r-f power into the measuring set as described in paragraph 1 of this section. To determine the power output of a radar transmitter, the losses of the various components in the transmission path between the transmitter and the input to the test set must be known. The average power output of the radar transmitter is then equal to the power in milliwatts measured above, multiplied by the power ratio of these losses. The peak power output of the transmitter can be computed from the average power if the db loss corresponding to the duty cycle is known.

d. COMPUTATION OF RADAR PEAK POWER OUTPUT.

(1) The rated power of a radar transmitter is usually expressed in terms of the peak pulse power. Meter TS-295/UP measures average power. In order to translate average power to peak power, the pulse repetition rate and the pulse width or duration must be known. The relation between the peak power and the average power is generally known as the duty cycle, and since it is a power ratio it may be expressed in db. The duty cycle in db as a function of pulses per second and pulse duration in microseconds is shown in Figure 4-3. Pulse rates of 120 to 8000 pulses per second and pulses from 0.25 to 4 microseconds duration are covered. The duty cycle for intermediate values of pulse length can be interpolated between the curves.

(2) In addition to the duty cycle, the transmission losses between the radar transmitter and the measuring set must be taken into account. When using a directional coupler, the loss through the coupler, which is marked on the unit, should be included. When using a test dipole, measure the loss between antennas. The 10-db loss in the connecting cable used with Meter TS-295/UP also must be added to the other losses when this cable is used.

(3) The following is a sample calculation for determining the transmitter peak power: Assume that the transmitter power of an SV radar system operating with a repetition rate of 400 and a pulse duration of one microsecond is being measured by means of the directional coupler, and that the power measured is 8 mw (9.0 dbm) using the 10-db connecting cable. The measured frequency is 100. The term "dbm" means power in db with respect to one milliwatt, i.e., +21 dbm is 31 db above one milliwatt, —3 dbm is 3 db below one milliwatt, etc.

Measured Values

Meter reading RF disconnected.....	13.0 mw
Meter reading RF connected.....	5.0 mw
R-f power into Meter TS-295/UP (mw)	8.0 mw

Figure 4-3. DB-Duty Cycle Chart

204173 O—52——3

Figure 4-4. Radar Test Equipment Model TS-295/UP Lid Showing Graphical Frequency Meter Card

Calculation of Power

R-f power into Meter TS-295/UP corresponding to 8 mw above (see Figure 4-1, page 4-0)	9.0 dbm	
Loss of 10-db connecting cable at freq. = 100 (see Figure 4-2, page 4-2)	9.8 db	
Loss of 3-db connecting cable (no freq. compensation)	3.0 db	
Loss through directional coupler*	34.0 db	
Average r-f power in radar r-f line	55.8 dbm	= 380 watts
Pulse duty cycle (see Figure 4-3, page 4-3)	34.0 db	
Peak power (see Figure 4-1, page 4-0)	89.8 dbm	= 950 kw

*The actual coupling loss of the directional coupler is measured at the factory and marked on the unit.

e. USE OF MEASURING SET IN MAXIMIZING RADAR POWER OUTPUT.

(1) When maximizing adjustments of radar power output are to be made, connect the power to be maximized to the MEAS PWR jack, and balance the bridge as described in paragraph 1*a*(3) of this section.

(2) Adjust the COARSE knob until the meter reads between 2 and 3 mw. Do not allow the reading to be any higher than 3 mw during this and following adjustments, with the GALV SENS key normal.

(3) Make necessary adjustments on the radar transmitter, noting movement of the test set meter. As power is increased, the meter needle will move toward zero. If needle moves below zero, readjust COARSE knob until meter reads 2 to 3 mw. Repeat the maximizing adjustments of the transmitter until the maximum power has been obtained (minimum meter reading).

(4) If greater accuracy is necessary, depress GALV SENS key and adjust FINE knob until meter reads approximately 15 mw. Repeat adjustment on transmitter as in (3) with the GALV SENS key depressed.

3. USE OF MEASURING SET IN ADJUSTING SIGNAL GENERATOR TO DESIRED POWER OUTPUT.

a. Balance the bridge with r-f power disconnected as described in paragraphs 1*a*(1) to 1*a*(3) of this section.

b. Operate the TEST key to the MEAS position and read the meter in milliwatts. The desired power must be less than this reading.

c. Subtract the desired power from the reading obtained in *b* above.

d. With the TEST key still in the MEAS position, adjust the COARSE and FINE controls until the meter reads the mw determined in *c* above. Release the TEST key.

e. Connect r-f power to the MEAS PWR jack.

f. Adjust the output of the signal generator until the bridge is balanced. Depress GALV SENS key for greater accuracy and readjust. The power is now at the desired value at the end of the connecting cable connected to the MEAS PWR jack.

4. MEASUREMENT OF REFLECTED POWER AND STANDING WAVE RATIO (SWR).

a. Measurements of direct and reflected powers are required to determine the standing wave ratio in the r-f transmission line of the radar equipment. The procedure for measuring reflected power is the same as that for measuring direct power except that connection is made at the directional coupler to the reflected power output jack.

b. Measure the direct and reflected powers and change mw power to dbm. (See Figure 4-1.) The db difference between the reflected power and the direct power can be expressed in terms of standing wave ratio. Voltage standing wave ratios corresponding to db differences between direct and reflected power are given in Table 4-1. If the reflected power is less than 0.5 mw, use the 5-foot low-loss cable in the connection to the measuring set. In this case it will be necessary to take into account the different losses of the cables, by calculating the powers at the directional coupler end of the cables. In almost all radars the VSWR should be less than 2 to 1. If the transmission line has a VSWR in excess of 5 to 1 the system probably needs an overhaul. Consult the radar instruction book for more specific information.

5. MEASUREMENT OF FREQUENCY WITH THERMISTOR AS INDICATOR.

a. A power input of at least 0.5 mw to the MEAS PWR jack is required for a satisfactory frequency measurement.

b. Connect the signal whose frequency is to be measured to the FREQ METER IN jack by means of the 10-db connecting cable CG-258/U.

c. Connect the FREQ METER OUT jack to the MEAS PWR jack using the short 6-inch patching cable.

d. Detune the frequency meter by turning the MEAS FREQ knob to the minimum reading.

e. Adjust the COARSE and FINE knobs until a bridge balance is obtained.

f. Turn the MEAS FREQ knob of the frequency meter slowly until a maximum deflection is obtained on the meter. If the r-f power is small (less than 4 mw) depress the GALV SENS key before turning the MEAS FREQ knob. When the meter needle has reached its peak, adjust COARSE and FINE knobs until needle is again at zero or slightly to right. Depress GALV SENS key and again adjust MEAS FREQ knob to give maxi-

TABLE 4-1

TABLE OF RELATIONS BETWEEN REFLECTED AND DIRECT POWER, VOLTAGE STANDING WAVE RATIOS (VSWR), AND REFLECTION LOSS.

*D-R**	*Corresponding VSWR†*	*Resulting db Reflection Loss in Radiation Power†*
∞	1.0	0
26.4	1.1	.005
20.8	1.2	.01
17.7	1.3	.04
15.6	1.4	.12
14.0	1.5	.16
12.8	1.6	.24
11.7	1.7	.30
10.9	1.8	.38
10.2	1.9	.44
9.6	2.0	.51
9.0	2.1	.58
8.5	2.2	.66
8.1	2.3	.73
7.7	2.4	.80
7.3	2.5	.88
7.0	2.6	.97
6.7	2.7	1.04
6.5	2.8	1.10
6.2	2.9	1.16
6.0	3.0	1.26
4.4	4.0	1.94
3.5	5.0	2.56
2.9	6.0	3.1
2.5	7.0	3.6
2.2	8.0	4.0
1.9	9.0	4.44
1.75	10.0	4.82
0.9	20.0	7.41

* D = Direct power in dbm, R = Reflected power in dbm.

† VSWR = The ratio of the maximum to the minimum voltage of the standing wave existing on the transmission line. Limiting values of VSWR are given in instruction books for some radars. The db reflection loss column expresses the db loss in power of the direct wave that is finally radiated from the antenna.

mum meter reading. The thermistor is a comparatively slow-acting device and care should be taken when close to the maximum position to move the dial very slowly in order that an accurate determination may be made.

g. Read the frequency indicator setting and determine the frequency from either calibration card which accompanies the measuring set.

h. For a typical example of the use of the frequency table see paragraph 7.

6. USES OF CRYSTAL.

a. AS DETECTOR FOR VIEWING PULSES ON OSCILLOSCOPE.

(1) Connect CRYSTAL IN jack to the pulsed r-f source to be measured. The peak power at the input jack of the crystal should not be allowed to exceed 1 watt (+30 dbm). The reflected power output of the directional coupler connected through the 10-db cable will usually meet this requirement.

(2) Connect an oscilloscope to the VIDEO jack. This oscilloscope should be self-triggering or synchronized with the transmitter sending out the pulsed power.

(3) The pulses can now be viewed on the oscilloscope.

b. MEASUREMENT OF FREQUENCY OF PULSED SIGNAL USING CRYSTAL.

(1) The crystal can be used to measure the frequency of pulsed r-f signals where the peak power does not exceed 1 watt (+30 dbm) at CRYSTAL IN jack.

(2) Connect the pulsed r-f source to be measured to the FREQ METER IN jack.

(3) Connect FREQ METER OUT plug to CRYSTAL IN jack.

(4) Connect VIDEO jack to an oscilloscope.

(5) With the frequency meter detuned, adjust the screen image on the oscilloscope to a convenient size for viewing.

(6) Tune the frequency meter until the center of the pulse image on the oscilloscope screen is reduced to a minimum. At this point the frequency meter is tuned to resonance.

(7) Read the frequency indicator setting and determine the frequency from either calibration card which accompanies the set, as described in paragraph 7.

7. FREQUENCY METER CALIBRATION CARDS.

a. GENERAL.—Each set contains three frequency meter calibration cards.

(1) A tabular frequency calibration card, mounted on the panel (see Figure 1-3), lists the indicator readings in 50-mc steps over the entire S_w band, and the megacycles per indicator division every 50 mc throughout the band. This card should be used for accurate frequency work.

(2) Two graphical frequency meter calibration cards are mounted in the lid of the set, one covering the frequency range from 0-300 (see Figure 4-4) and the other 200-500. In general, the 0-300 card will cover all SV equipments.

CAUTION

Before using calibration cards in the lid, check that the frequency meter cavity number on the chart agrees with the cavity number on the panel calibration card.

b. TABULAR FREQUENCY METER CALIBRATION CARD.

(1) The following is a typical card:

FREQUENCY CALIBRATION

Frequency	*Indicated Reading*	*Mc/Div.*
0	1943	.26
50	2129	.27
100	2309	.28
150	2485	.29
200	2655	.30
250	2821	.30
300	2982	.31
350	3139	.32
400	3292	.33
450	3441	.34
500	3586	.35

Cavity Serial No.

(2) EXAMPLE OF USE OF TABULAR FREQUENCY METER CALIBRATION CARD.—The following are examples of the use of the frequency calibration, using the card above as a typical illustration.

Determination of Frequency From Observed Meas Freq Indicator Readings:

Directions	*Example*
(1) Call the observed indicator reading R	For example, assume R = 2421.1
(2) Find INDIC RDG on card closest to R	Closest INDIC RDG is 2485.0
(3) Subtract to find difference between (1) and (2)	(2) − (1) = 63.9
(4) Multiply difference by value of MC/DIV opposite (2) on card	63.9 × .29 = 18.5
(5) Note the number opposite (2) in FREQ column on card	Freq. No. is 150
(6) Add results of (4) and (5) if (2) is smaller than R, otherwise subtract (4) from (5)	(2) (2485.0) is larger larger than R (2421.1). So frequency = 150 − 18.5 = 131.5

Determination of Indicator Setting for Desired Frequency:

Directions	*Example*
(1) Call desired frequency F	Assumed desired frequency is 360
(2) Find calibrated frequency closest to F (number in the FREQ column)	Nearest calibration is 350
(3) Determine difference between nearest calibrated frequency and F	360 − 350 = 10
(4) Divide difference by value of MC/DIV opposite number in (2)	$\frac{10}{.32} = 31.2$
(5) Find INDIC RDG opposite number in FREQ column	3139.6
(6) Add results of (4) and (5) if calibrated frequency is lower than F, otherwise subtract (4) from (5). Set MEAS FREQ indicator at this value.	Calibration frequency (350) is lower than F (360). MEAS FREQ indicator reading should be 3139.6 + 31.2 = 3170.8. Set MEAS FREQ Indicator at 3170.8.

c. GRAPHICAL FREQUENCY METER CARDS.

(1) Each of the two graphical frequency meter calibration cards (see Figure 4-4), will generally contain five or more curves for determining frequency from indicator readings, or indicator reading for a given frequency. Each curve is associated with a two-letter combination indicating with which abscissa (horizontal) and ordinate (vertical) lines it is to be used, i.e. curve CX would mean to use abscissa line C (indicator reading 2500-3000) and ordinate line X (frequency between 200 and 300).

(2) The purpose of this card is to make available a ready means of determining the approximate frequency and to determine the indicattor reading corresponding to a change of 60 mc for setting the B.O. frequency.

(3) This card may also be used to check results when using the tabular frequency chart.

(4) The frequency meter indicator readings corresponding to upper and lower frequency limits of the SV transmitter are shown on calibration card no. 1 as "RADAR RANGE INDICATOR READING FROM ..... TO ....."

8. DETAILED EXAMPLE OF DETERMINING POWER AND FREQUENCY OF SV TRANSMITTER.

a. Start the radar equipment as described in the radar instruction book.

b. Measure the power as follows:

(1) Turn the ADJUST CURRENT knobs COARSE and FINE in a counterclockwise direction as far as they will go.

(2) Operate the BAT switch to ON.

(3) Adjust COARSE and FINE knobs until the meter reads between zero and 0.5 mw.

(4) Depress the GALV SENS push button and adjust the COARSE and FINE knobs until the meter reads zero.

(5) Operate the TEST key to the MEAS position and read the meter in mw. Record this reading as item 1 on the chart in Figure 4-6.

(6) Turn the COARSE and FINE knobs in a counterclockwise direction as far as they will go.

(7) Connect the direct power jack of the directional coupler in the radar transmission line to the MEAS PWR jack of TS-295/UP, using the 10-db connecting cable CG-258/U. See Figure 4-5.

(8) Adjust the COARSE and FINE knobs until the meter reads between zero and 0.5 mw.

(9) Depress GALV SENS push button and adjust the COARSE and FINE knobs until the meter reads zero.

(10) Operate the TEST key to the MEAS position and read the meter in mw. Record this reading as item 2 on the chart in Figure 4-6.

(11) The r-f power into the TS-295/UP is the meter reading in step (5) minus the meter reading in step (10).

(12) Fill in the remaining blanks in Figure 4-6 in accordance with the instructions given on the form. Items 13 to 16 need be filled in only when it is desired to know the peak power.

c. Measure frequency as follows:

(1) Connect the direct power jack of the directional coupler to the FREQ METER IN jack of TS-295/UP. (See Figure 4-5.)

(2) Connect the FREQ METER OUT jack to the MEAS PWR jack using the short patch cable CG-256/U.

(3) Operate BAT switch to ON.

(4) Detune the frequency meter by turning the MEAS FREQ knob at least 200 divisions from the setting corresponding to the expected radar frequency.

(5) Adjust the COARSE and FINE knobs till the meter reads between zero and 0.5 mw.

(6) Depress the GALV SENS push button and adjust the COARSE and FINE knobs until the meter reads zero.

(7) Rotate the MEAS FREQ knob until a maximum deflection is obtained on the meter.

(8) Depress the GALV SENS button and adjust the COARSE and FINE knobs until the meter again reads zero or nearly zero.

(9) With the GALV SENS button still depressed, again adjust the MEAS FREQ knob to give the maximum meter deflection. Care should be taken when close to the maximum position to move the dial very slowly in order that an accurate determination may be made.

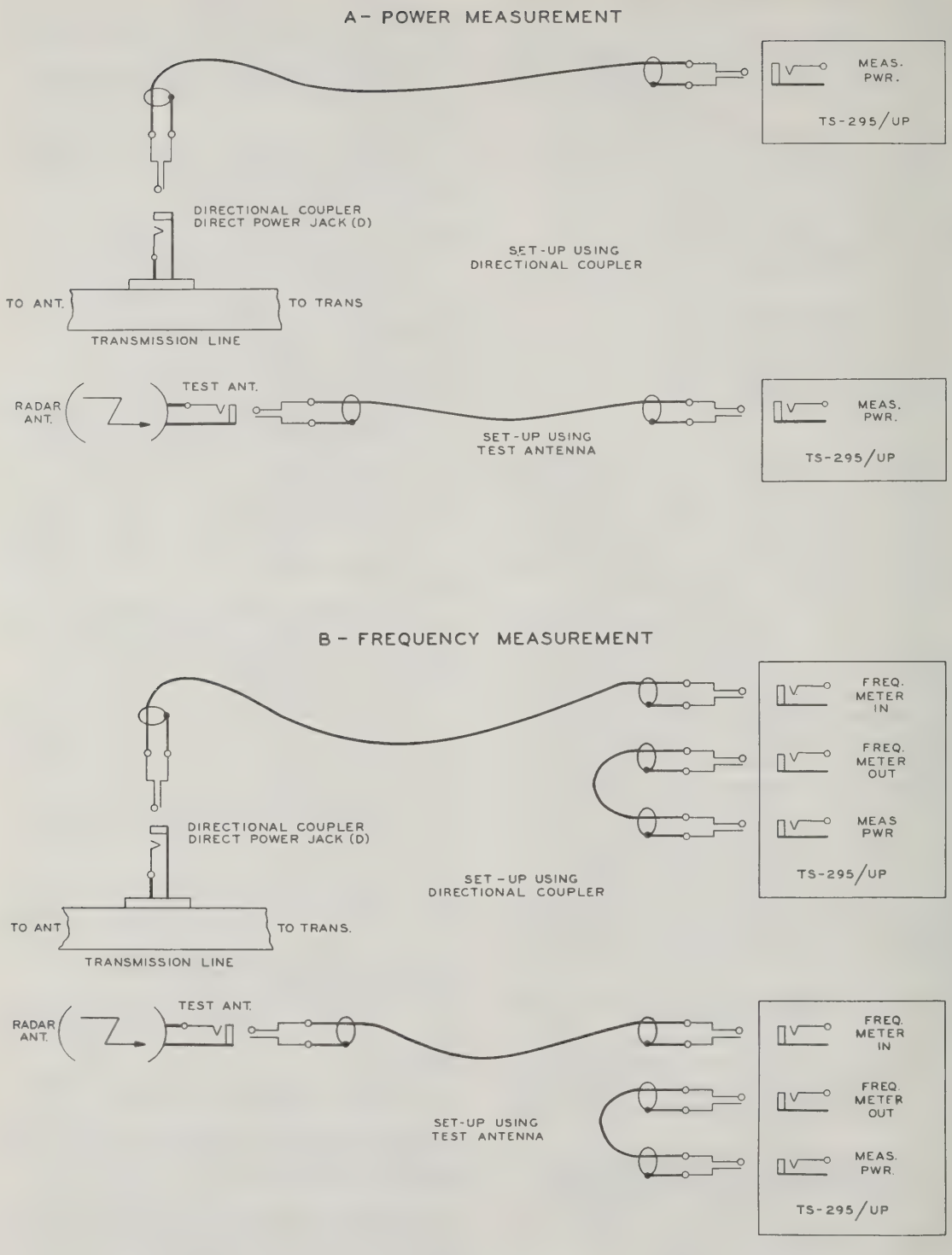


Figure 4-5. Radar Test Equipment Model TS-295/UP Diagram of Connections for Measuring Power and Frequency of Radar Transmitter

RECORD OF TRANSMITTER POWER MEASUREMENTS

Serial number of radar being measured. 2467

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date 10/20/45				
1. Meter Reading (R-F disconnected)	mw	13.0				
2. Meter Reading (R-F connected)	mw	7.6				
3. Average R-F Power (Item 1—Item 2)	mw	5.4				
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm	7.3				
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db	10.0				
6. 3-db Cable Loss (if used, no correction)	db	—				
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db	35.0				
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db	1.0				
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm	53.3				
10. Rated average power output of transmitter	dbm	54.3				
11. Measured average power (Item 9)	dbm	53.3				
12. Difference between measured and rated average power (Items 10 and 11. Record as — if measured power is the smaller, + if measured power is the greater.)	db	-1.0				

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm	53.3				
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db	34.0				
15. Peak Power (Item 13 + Item 14)	dbm	87.3				
16. Convert Item 15 to kw (See Fig. 4–1)	kw	537				

Figure 4-6. Chart Showing Typical Power Measurement on SV Radar

(10) Read the frequency indicator setting. For this example assume the setting is 2421.1.

(11) On Tabular Frequency Meter Calibration card find the nearest INDIC RDG as 2485.0.

(12) Find the difference between (10) and (11) as 63.9.

(13) Multiply (12) by MC/DIV opposite (11) on card. 63.9 X .29 = 18.5.

(14) Note the number opposite (11) in FREQ column as 150.

(15) Subtract (13) from (14). 150 — 18.5 = 131.5, the frequency.

SECTION V
OPERATOR'S MAINTENANCE

1. REMOVAL OF SET FROM BOX.

a. The chassis is fastened to the box by four screws at the corners of the panel (see Figure 1-3). Remove chassis by loosening these screws, and fasten into brackets.

2. REPLACING BATTERIES.

a. Operate TEST key to MEAS; turn COARSE and FINE knobs to extreme clockwise position. The meter should read at least 20 mw with no r-f connected. If it reads lower, replace batteries as follows: The batteries are mounted in a cylindrical battery box on the chassis and are held in place by a plate fastened with screws. (See Figure 7-1.) Remove the plate designated "For Battery Replacement" and remove the old batteries. Insert the new batteries with the positive terminals (top terminals in sealing wax end) facing inward.

3. REPLACING THERMISTOR.

a. If the meter always reads high and cannot be brought to zero when making an attempt to d-c balance the bridge, an open thermistor is indicated. A spare thermistor is carried in a container under the knurled cap designated SPARE THERM. When removing the spare thermistor, leave the small piece of felt surrounding the thermistor in the container. The procedure for removing the old thermistor from the r-f chamber and inserting a new one is as follows:

(1) Remove the four small machine screws near the center of the r-f chamber where the square and round portions meet. (See Figure 2-2.)

(2) Separate the two parts of the assembly and remove the thermistor from the split chuck ends of the central conductor.

(3) Insert the leads of the new thermistor in the ends of the central conductor with the metal collar end of the thermistor toward the round portion of the assembly. Push the two parts of the chamber assembly together, taking care to maintain approximate alignment so that the split chucks will not be sprung.

(4) Replace the four screws in the r-f chamber assembly.

4. REPLACING CRYSTAL.

a. When using the crystal in Section IV paragraph 6 and there is no rectified current or too little current, replace the crystal as follows: The crystal block is mounted with the CRYSTAL IN and VIDEO jacks on the back of the panel and the block itself supported by the jacks and an attachment to the r-f chamber. A spare crystal is carried in the container under the knurled cap designated SPARE CRYSTAL.

b. CAUTION IN HANDLING CRYSTAL.—The electrical characteristics of the crystal will be impaired to a measurable extent as a result of the passage of excessive electrical currents through the unit. Minute static charges not readily detectable are sufficient to cause damage. The crystal should, therefore, not be exposed to static discharge shocks. Static may be accumulated, particularly in dry weather, by the motion of the operator's feet across an insulated floor. If the apparatus into which the crystal is to be inserted is not grounded, the apparatus may have accumulated a static charge. In either case, there is a possibility of damage to the crystal due to the passage of electrical discharge currents through it. This possibility of damage may be avoided by touching the hand which holds the new crystal to the crystal block before and while inserting the new crystal in the block. Similarly, the knurled cap shall be touched to the crystal block before attaching the cap to the crystal. The crystal may also be damaged by power absorbed from intense fields, set up by a nearby operating radar transmitter, which may be sufficient to overload and damage the crystal. The hazard from this source is greatly reduced by retaining the metal foil wrapping around the crystal

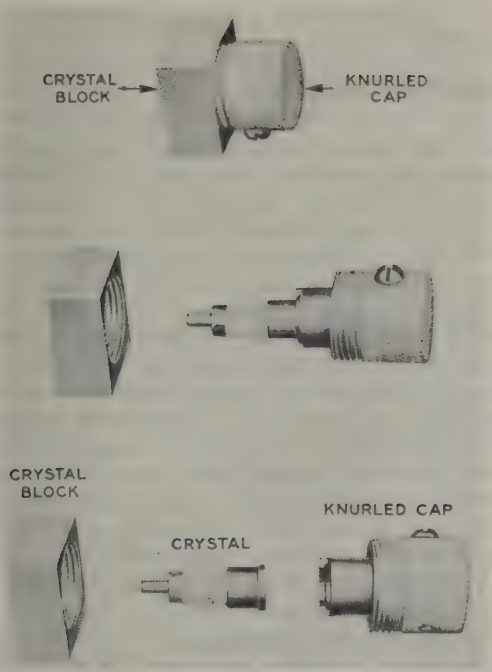


Figure 5-1. Method of Removing Crystal

until it is to be placed in the crystal block and by shutting down the radar transmitter before removing the metal foil wrapping and while inserting the crystal in the block.

c. PROCEDURE.

(1) Unscrew the large knurled cap at the end of the crystal block. Pull it out and, since the crystal is mounted on it, the crystal will come with it.

(2) The method of removing the crystal is shown in Figure 5-1. Grip the left end of the cap assembly. Unscrew the cap one-half turn to release the cartridge.

(3) With no nearby radar transmitter operating, remove the metal foil from the new crystal.

(4) Place the new crystal in the holder and fasten it in the holder by turning the knurled cap.

(5) Insert the crystal, mounted on the knurled cap, in the crystal block, being careful that the top of the crystal is properly seated in the chuck which holds it.

5. 10-DB AND 3-DB CONNECTING CABLES.

Never attempt to repair the 10-db and 3-db connecting cables. If either is damaged, replace it by a spare.

SECTION VI

PREVENTIVE MAINTENANCE

Note

The attention of maintenance personnel is invited to the requirements of Chapter 67 of the "Bureau of Ships Manual," of the latest issue.

1. Occasionally perform test of paragraph 2 in Section V to determine that the batteries are good. Also note that there is a spare crystal and a spare thermistor in the holder on the panel.

2. CALIBRATION OF CABLES.

a. Cables are apt to change their loss with time and use, especially if subjected to much bending. Therefore, they should be recalibrated occasionally. Proceed as follows:

b. Obtain a signal generator capable of generating frequencies in the SW band.

c. Set the frequency at 200, measured with a TS-295/UP as described in Section IV, paragraph 5.

d. Assuming the signal generator output is jack-ended, connect the signal generator output to the TS-295/UP with the CG-256/U cable (negligible loss). Set the output at approximately 10 mw, measured with a TS-295/UP as described in Section IV, paragraph 3.

e. If the cable to be measured is plug-ended at both ends, substitute it for the CG-256/U cable. If the cable to be measured is jack-ended at one end only, add this cable in series with the CG-256/U cable.

f. Measure the power received by the TS-295/UP.

g. Divide power measurement in *d* by the power measurement in *f*.

h. Convert the ratio obtained in *g* to db using the milliwatt curve in Figure 4-1, e.g., a power ratio of 9 is 9.6 db.

i. If the result differs from the rated value or from the last previous measured value by more than 0.5 db, obtain a new cable or record the new measurement and use it as the corrected value in all calculations.

SECTION VII
CORRECTIVE MAINTENANCE

CAUTION

Do not attempt to repair the frequency meter. Do not attempt to remove or unscrew the smaller of the two milled knobs on the crystal block. This is a quarter wavelength stub whose center conductor is soldered in place. (See Figure 7-1.) Observe the cautions given in Section V for handling crystals.

1. BRIDGE TROUBLE.

a. Should the accuracy of the meter in the bridge circuit be suspected, check the TEST key contacts by inspection and with ohmmeter. Before using ohmmeter, remove wire from one of the d-c milliammeter terminals. To check the meter, connect an external calibrated milliammeter (0-50 ma) of ½ per cent accuracy in series with the internal battery. Operate the TEST key to MEAS position and the BAT switch to ON. Adjust the COARSE and FINE knobs to give a full-scale reading of 22½ mw on the meter in the set. If this reading is not met, adjust COARSE and FINE controls until external meter reads 30 mils. Adjust R110 inside the set until test set meter reads full scale (22½ mw). If this results in a position of R110 close to its minimum and the adjustment is very critical, it is an indication that the fixed shunt is open or is greatly in excess of 4.4 ohms. Check this by: (1) disconnecting the leads from the meter in the set; (2) operating the BAT key to ON; (3) disconnecting the lead to the negative side of the battery; (4) measuring with a Wheatstone resistance measuring bridge the resistance between the leads which normally connect to the meter. This should measure 3.90 ohms ± 1% and R110 should be more than ¼ of the way from minimum position. If this requirement is not met, change R106 as required. If the shunts are satisfactory, replace the meter in the set with an identical meter.

2. SOME SPECIFIC TROUBLES.

Some specific troubles, their symptoms, the method of checking, and remedies are listed below.

Symptoms	*Possible Trouble*	*How to Check*	*Remedy*
a. In attempting to balance bridge, no reading on meter for any position of COARSE control	BAT switch on OFF	Observation	Operate BAT switch to ON
	BAT voltage zero or very low	Perform test described in Section V, paragraph 2	Replace batteries
	Open in circuit through bat., R108, R109 and BAT switch	Check with ohmmeter. BAT switch OFF	Replace defective apparatus or repair open in wiring or in switch contact
	Meter circuit open	Remove wires from meter before checking with ohmmeter	
	Meter open	Check per par. 1	Replace defective meter
b. No meter reading with TEST key on MEAS although there is a reading with TEST key in BAL position	R106 shorted or short in key contacts	BAT switch ON. Disconnect wires from meter and from neg. term. of bat. Use ohmmeter. Check key contact especially	Replace defective apparatus or repair short in wiring or key contact
c. In attempting to balance bridge, there is an irregular motion of needle	Poor contact in COARSE or FINE pots. or in wiring, or in TEST key contacts	BAT switch OFF. Check with ohmmeter	Replace pot. or establish good circuit in key or wiring
	Meter needle sticks	BAT switch ON. Test key to MEAS. Rotate COARSE control	Replace meter

Symptoms	*Possible Trouble*	*How to Check*	*Remedy*
d. In attempting to balance bridge, meter reads below zero for all pos. of COARSE and FINE pots.	Short around the thermistor or in the dielectric washers. See fig. 2–2	Remove thermistor. BAT switch OFF. Check res. from insulated terminal at round end of r-f chamber to its framework. Res. should be approx. 300 ohms. O reading indicates a short around the thermistor, probably at the dielectric washers	Remove shorting particles or replace r-f chamber. Examine space around rod at end of r-f chamber for metallic particles. If necessary, unscrew plug assembly at end of r-f chamber and examine dielectric washers
	R102 low res. or shorted	BAT switch OFF. TEST key on MEAS. Res. across R102 should measure 75 ± 0.8 ohms	Replace defective R102
	R101 or R103 high res. or open	BAT switch OFF. TEST key on MEAS. Measure across each res. Should be 75 ± 0.8 ohms. Open res. shows as 300 ohms if others are good. If 100 ohms is measured, the res. is good and one of the others open	Replace resistor in trouble
e. In attempting to balance bridge, meter reads high and cannot be brought to balance with COARSE and FINE controls	Thermistor improperly inserted or thermistor open-circuited	Same method as in *d.* above except an open thermistor shows as 300 ohms (R101, R102 and R103 in series)	Make certain that each end of thermistor rod is inserted in the chuck end of the center conductor or replace thermistor
	R102 high res. or open	BAT switch OFF. TEST key on MEAS. Measure across R102. Res. should be 75 ± 0.8 ohms. An open shows as 300 ohms (R101, R103 and R104 in series). If higher than 76 ohms, unsolder R102 and check it for 100 ± 1 ohms	If more than 1 ohm from 100 ohms, replace R102
	R101 or R103 low res. or shorted	BAT switch OFF. TEST key on MEAS. Measure across each res. Should be 75 ± 0.8 ohms	Replace resistor in trouble
	Bat. voltage too low to cause current through meter to reach a peak	Check bat. per par. 2 of Sec. 5	Replace battery
f. In attempting to balance bridge, operation of GALV SENS key has no effect	GALV SENS key contacts dirty	Ohmmeter	Clean contacts of GALV SENS key
	GALV SENS key or R105 shorted	In this case the meter will be very sensitive even with the FINE control. Check GALV SENS key and R105 with ohmmeter. TEST key on MEAS and BAT switch OFF	

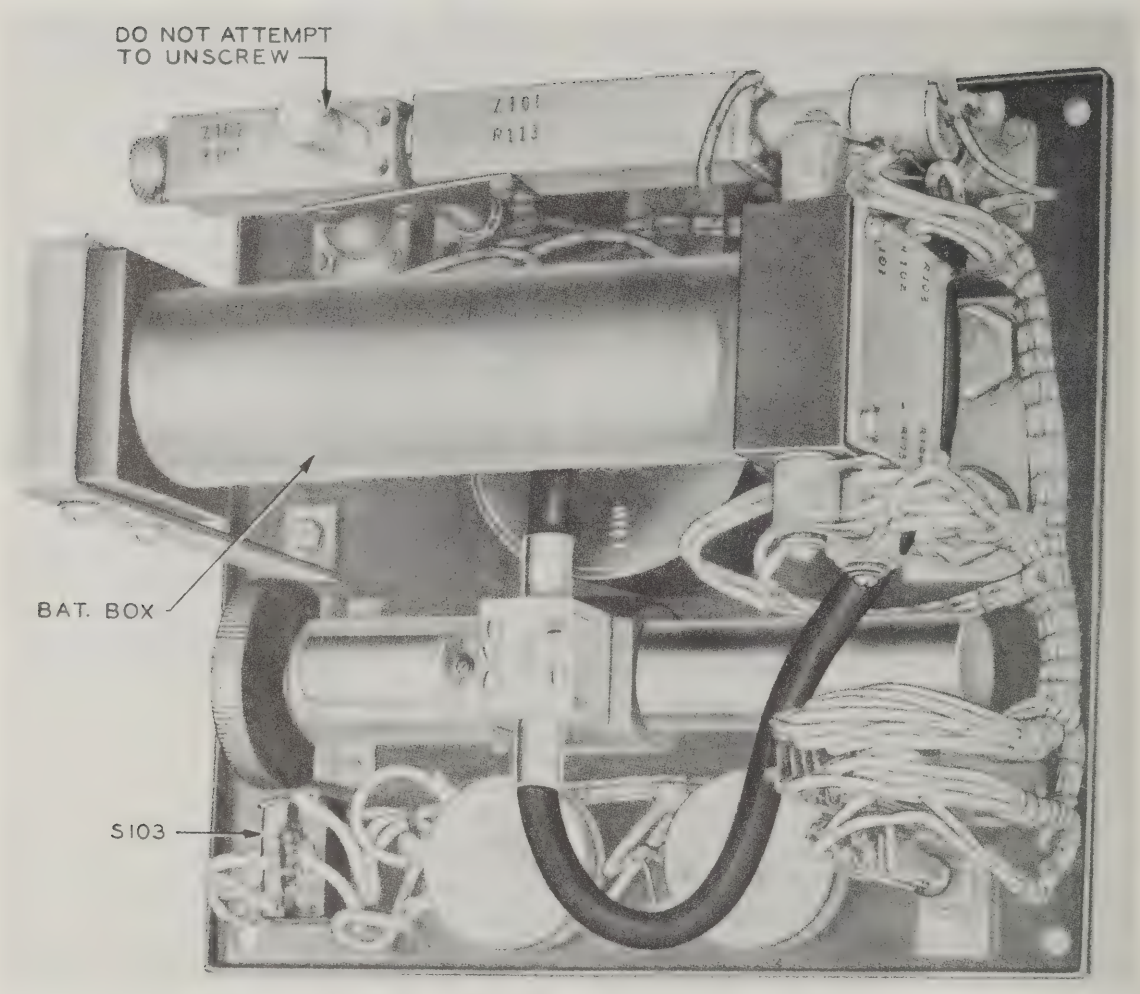


Figure 7-1. Radar Test Equipment Model TS-295/UP Rear View of Chassis

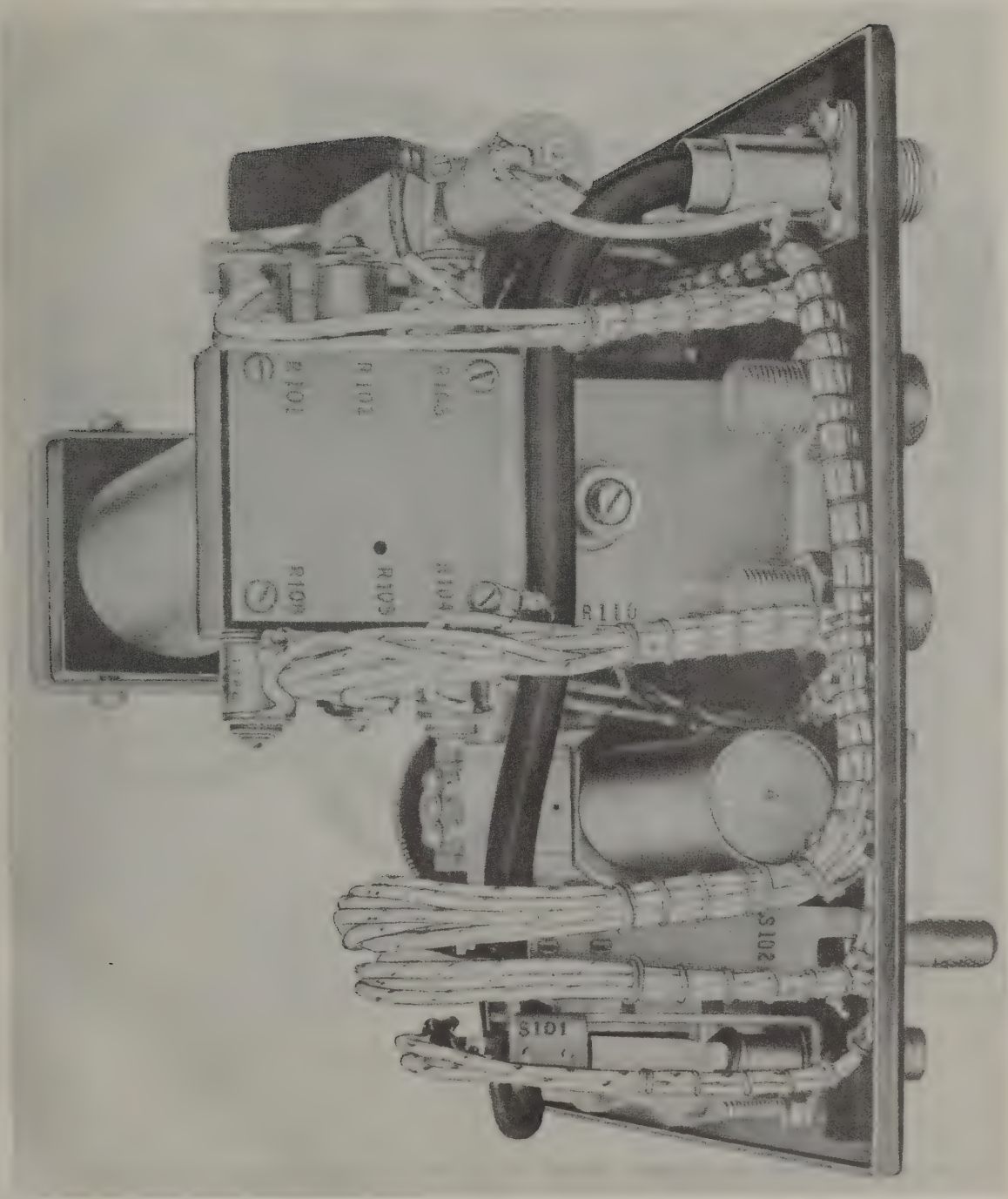


Figure 7-2. Radar Test Equipment Model TS-295/UP Side View of Chassis

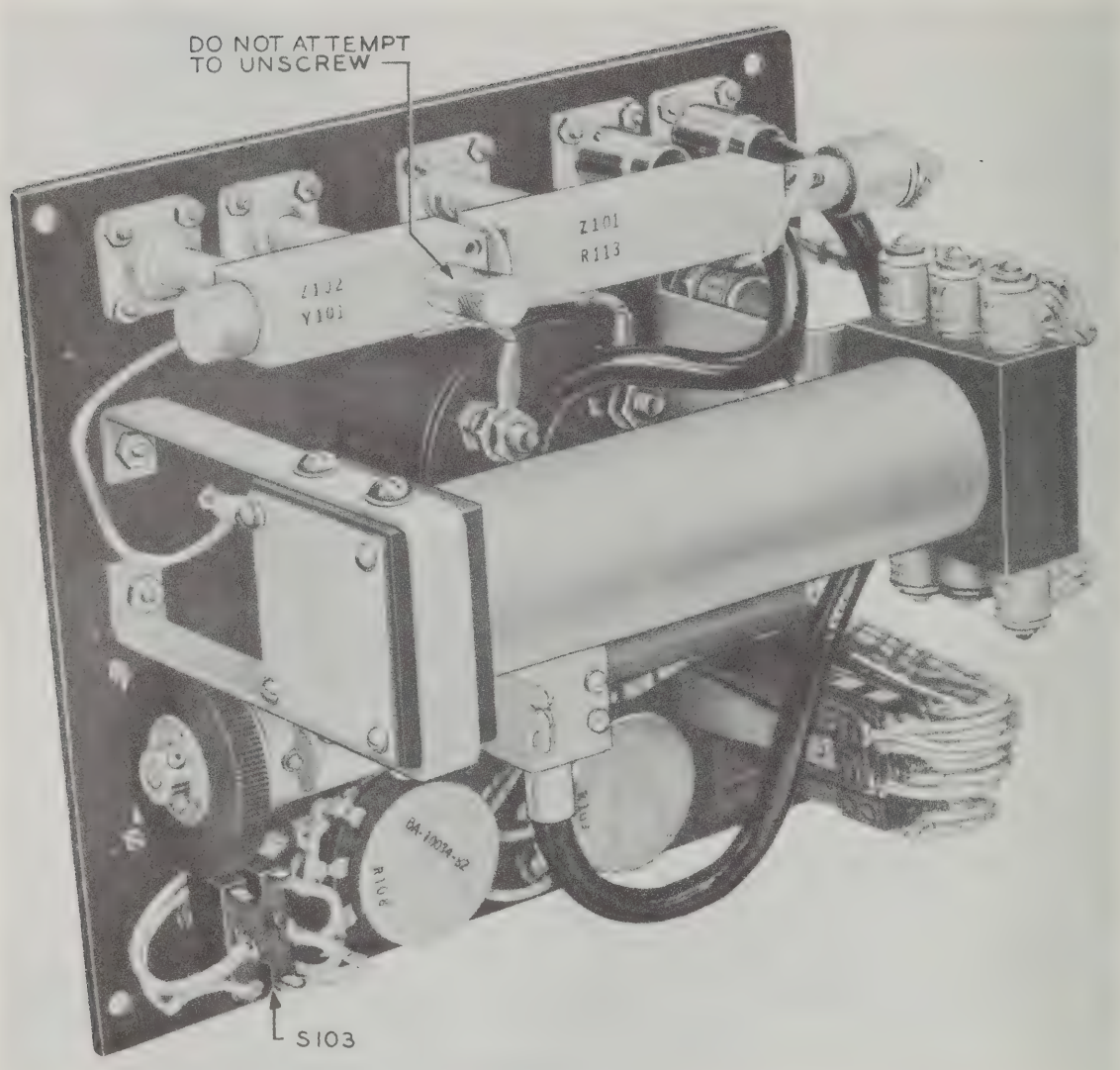
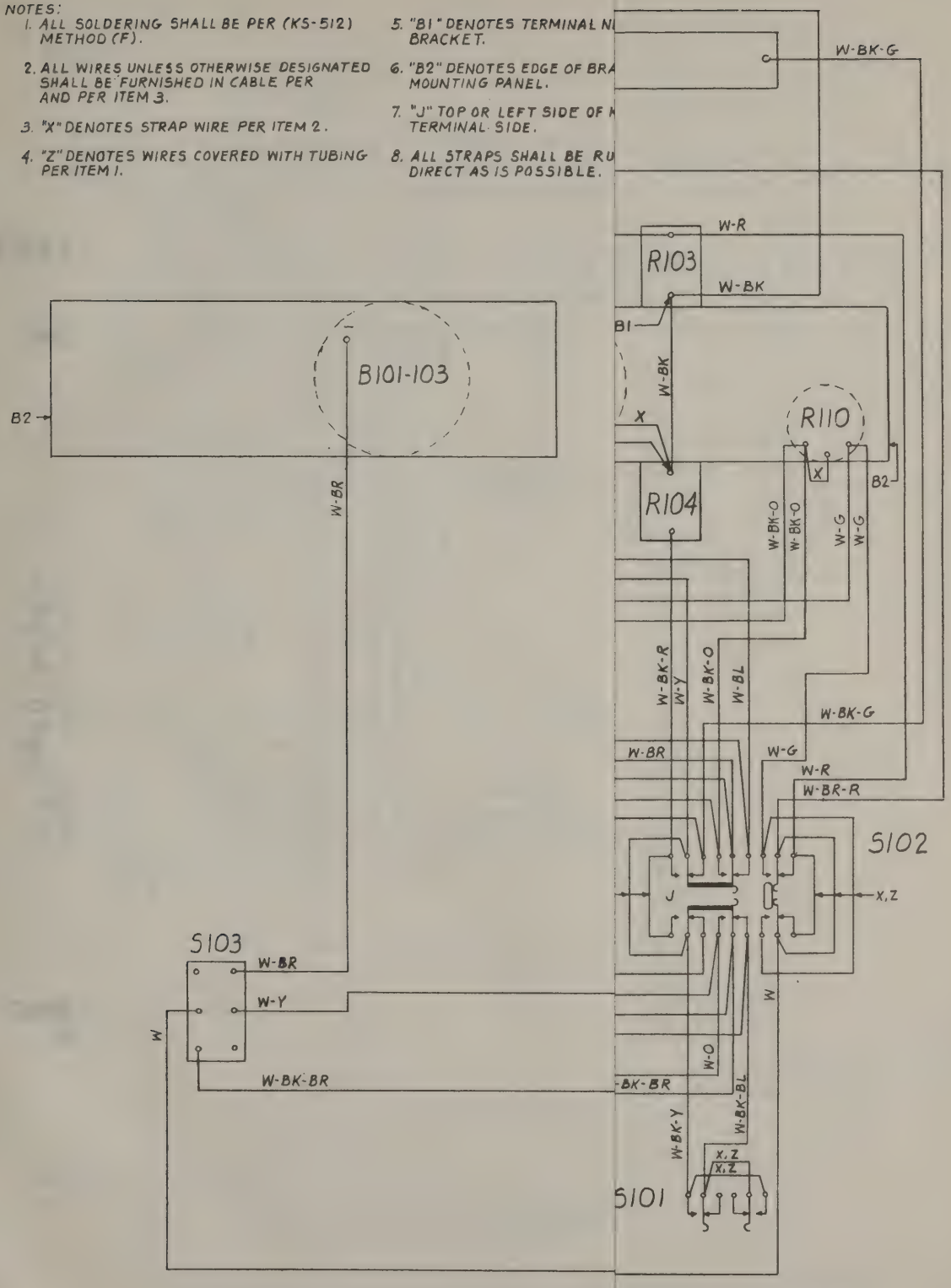


Figure 7-3. Radar Test Equipment Model TS-295/UP Rear View of Chassis from Left Side

NOTES:

1. ALL SOLDERING SHALL BE PER (KS-512) METHOD (F).
2. ALL WIRES UNLESS OTHERWISE DESIGNATED SHALL BE FURNISHED IN CABLE PER AND PER ITEM 3.
3. "X" DENOTES STRAP WIRE PER ITEM 2.
4. "Z" DENOTES WIRES COVERED WITH TUBING PER ITEM 1.
5. "B1" DENOTES TERMINAL NU BRACKET.
6. "B2" DENOTES EDGE OF BRA MOUNTING PANEL.
7. "J" TOP OR LEFT SIDE OF H TERMINAL SIDE.
8. ALL STRAPS SHALL BE RU DIRECT AS IS POSSIBLE.



TS-295/UP Wiring Diagram

204173 O—52——2

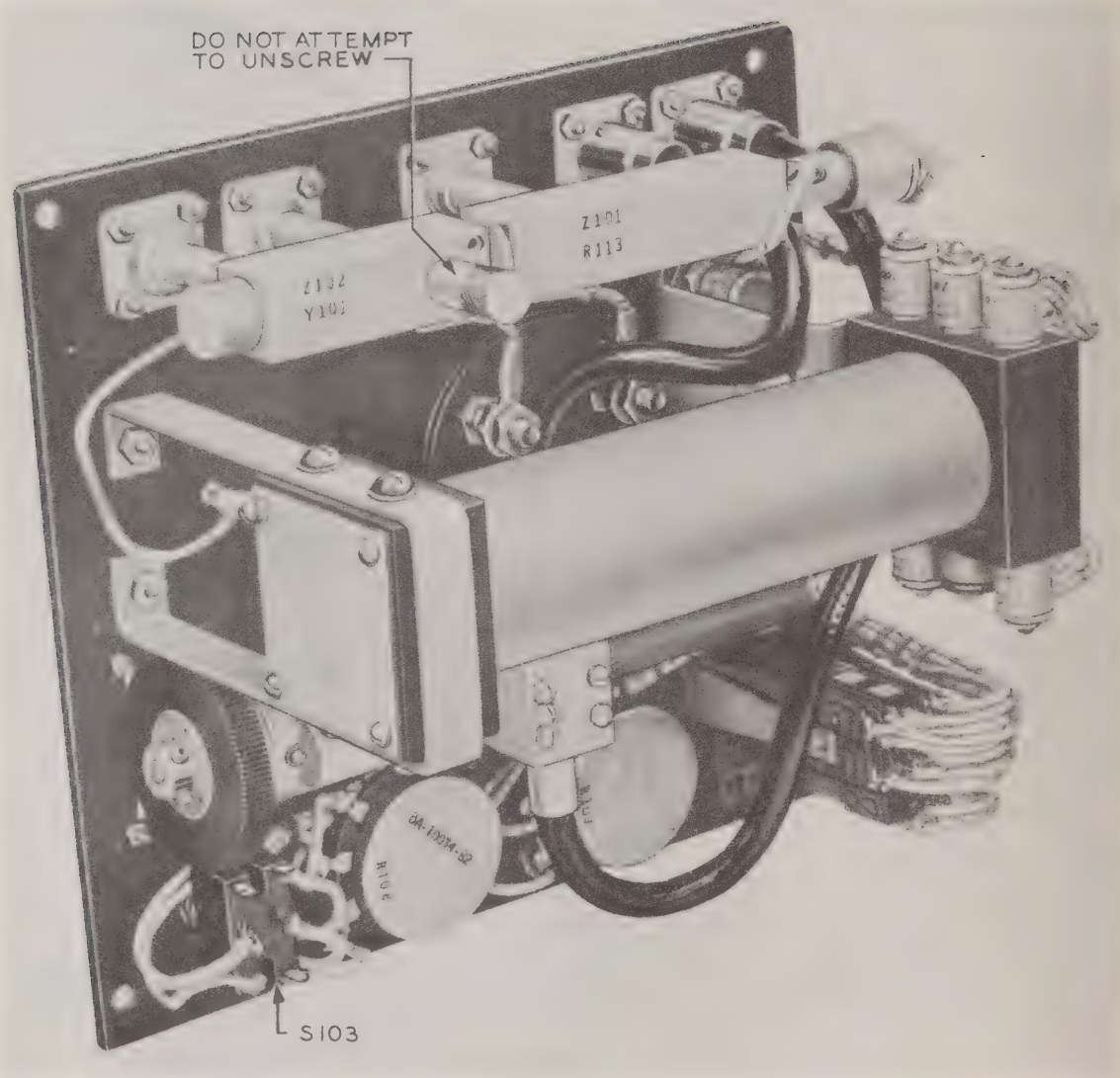


Figure 7-3. Radar Test Equipment Model TS-295/UP Rear View of Chassis from Left Side

NOTES:

1. ALL SOLDERING SHALL BE PER (KS-512) METHOD (F).
2. ALL WIRES UNLESS OTHERWISE DESIGNATED SHALL BE FURNISHED IN CABLE PER AND PER ITEM 3.
3. "X" DENOTES STRAP WIRE PER ITEM 2.
4. "Z" DENOTES WIRES COVERED WITH TUBING PER ITEM 1.
5. "B1" DENOTES TERMINAL NEAREST MOUNTING BRACKET.
6. "B2" DENOTES EDGE OF BRACKET NEAREST MOUNTING PANEL.
7. "J" TOP OR LEFT SIDE OF KEY LOOKING AT TERMINAL SIDE.
8. ALL STRAPS SHALL BE RUN AS SHORT AND AS DIRECT AS IS POSSIBLE.

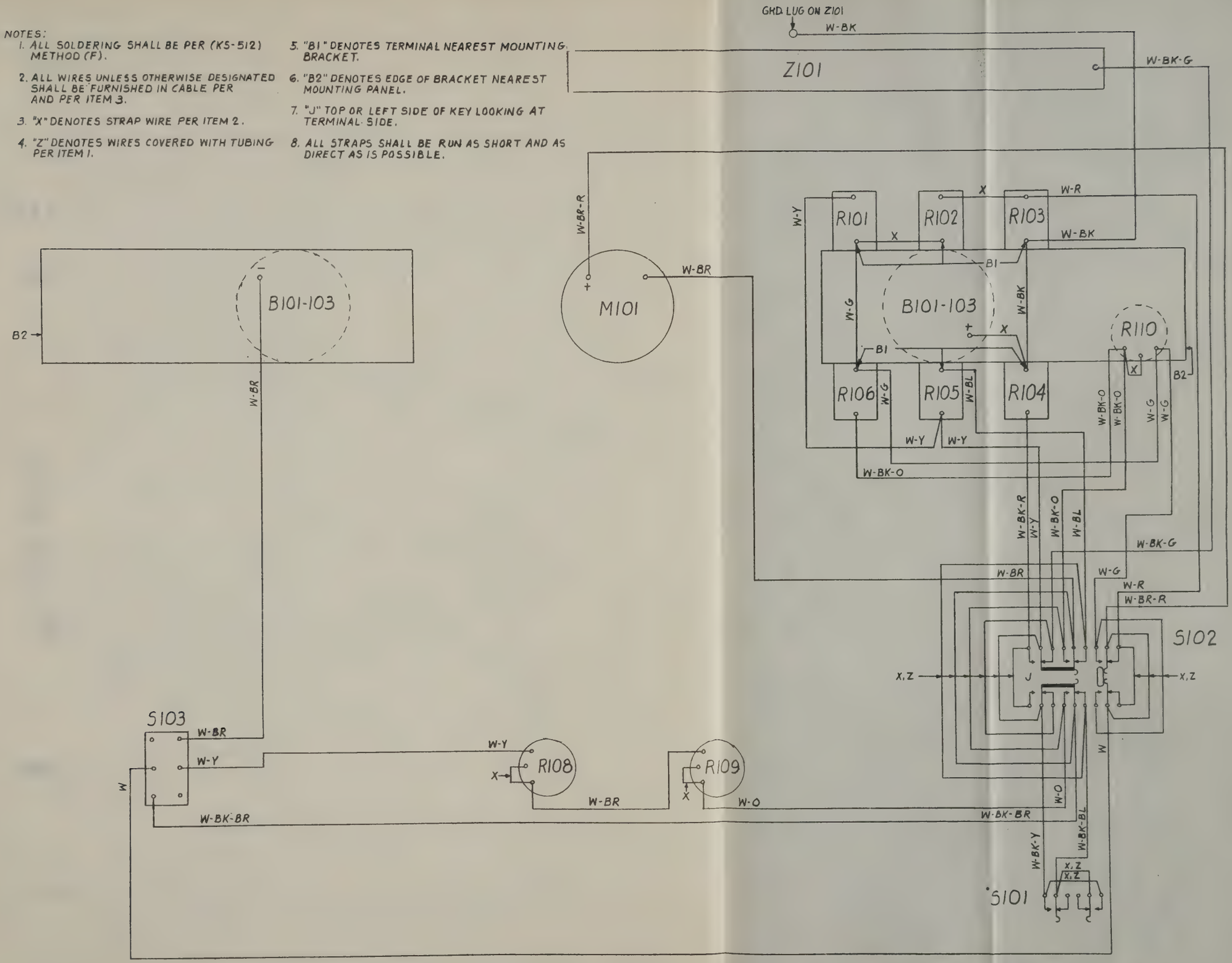
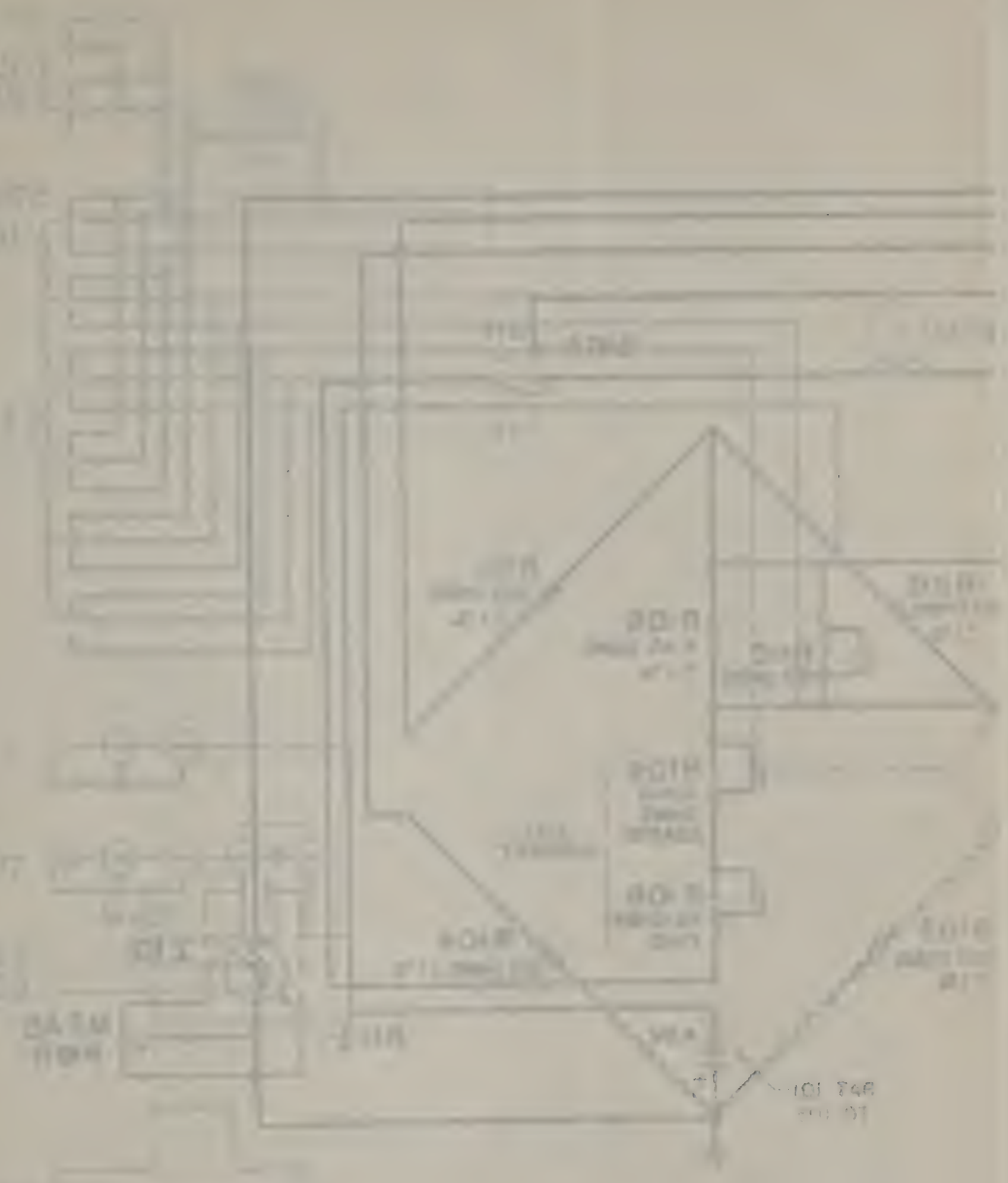
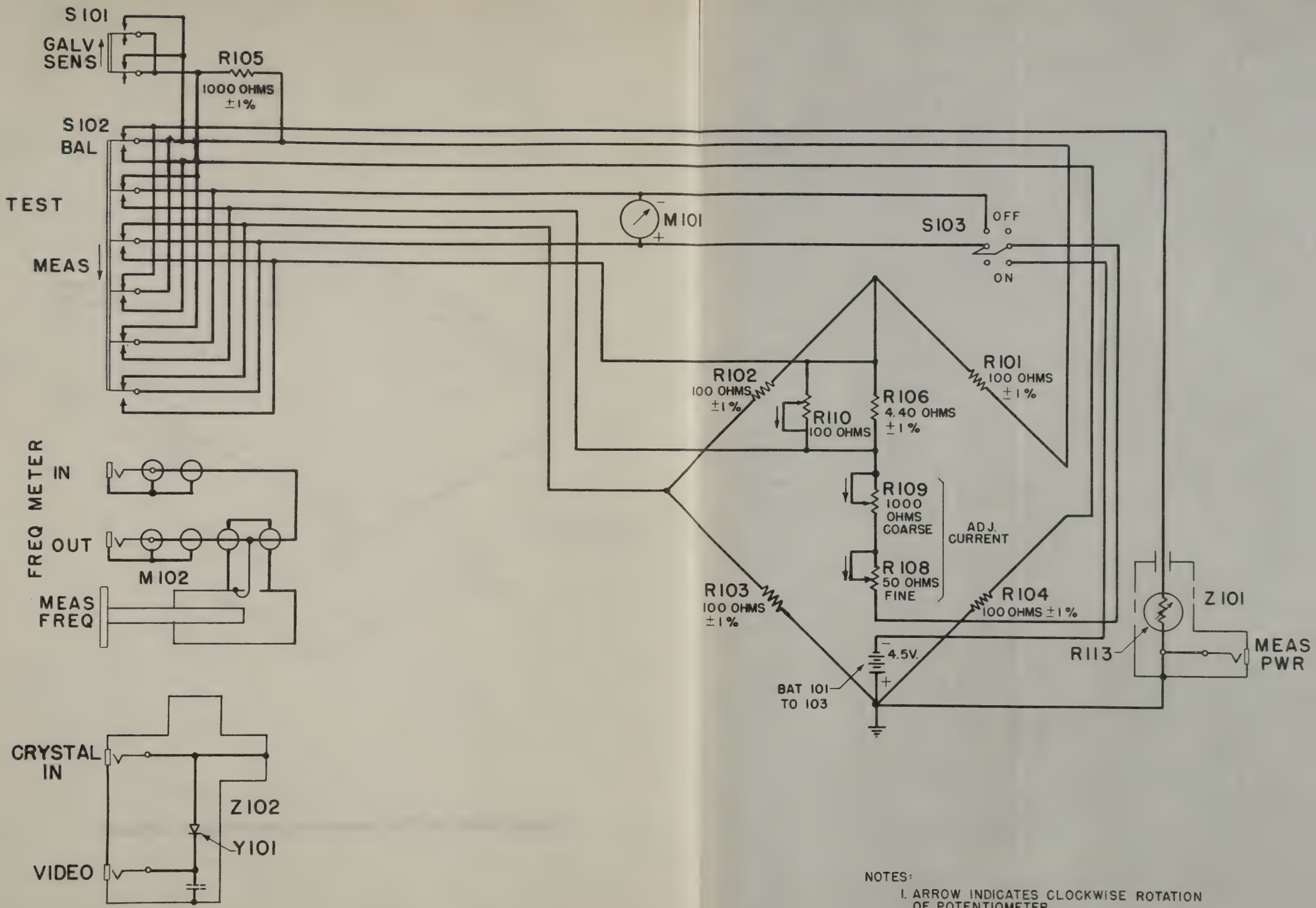


Figure 7-4. Radar Test Equipment Model TS-295/UP Wiring Diagram

204173 O—52——2



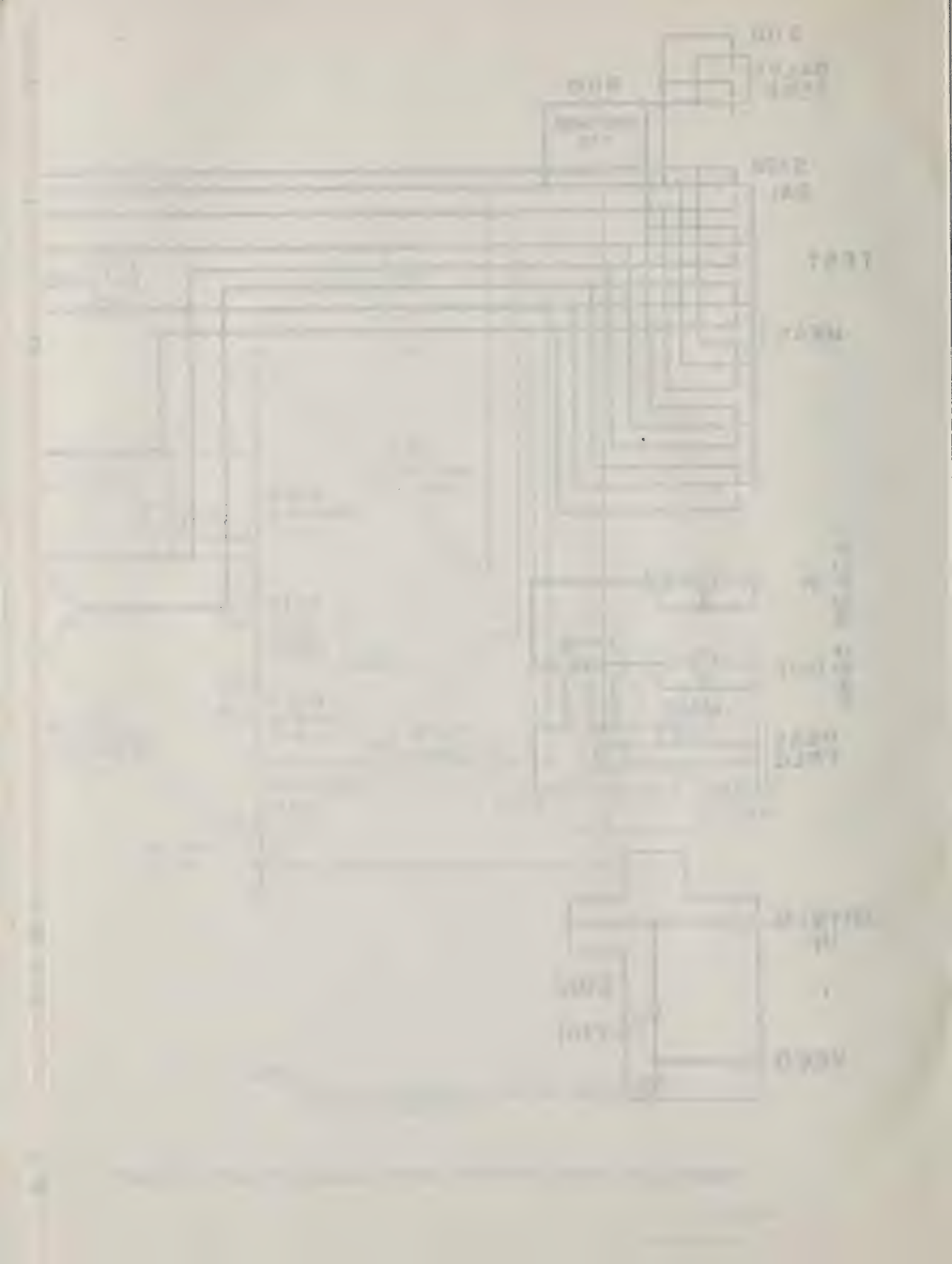


NOTES:

1. ARROW INDICATES CLOCKWISE ROTATION OF POTENTIOMETER.

Figure 7-5. Radar Test Equipment Model TS-295/UP Schematic Wiring Diagram

204173 O—52—3



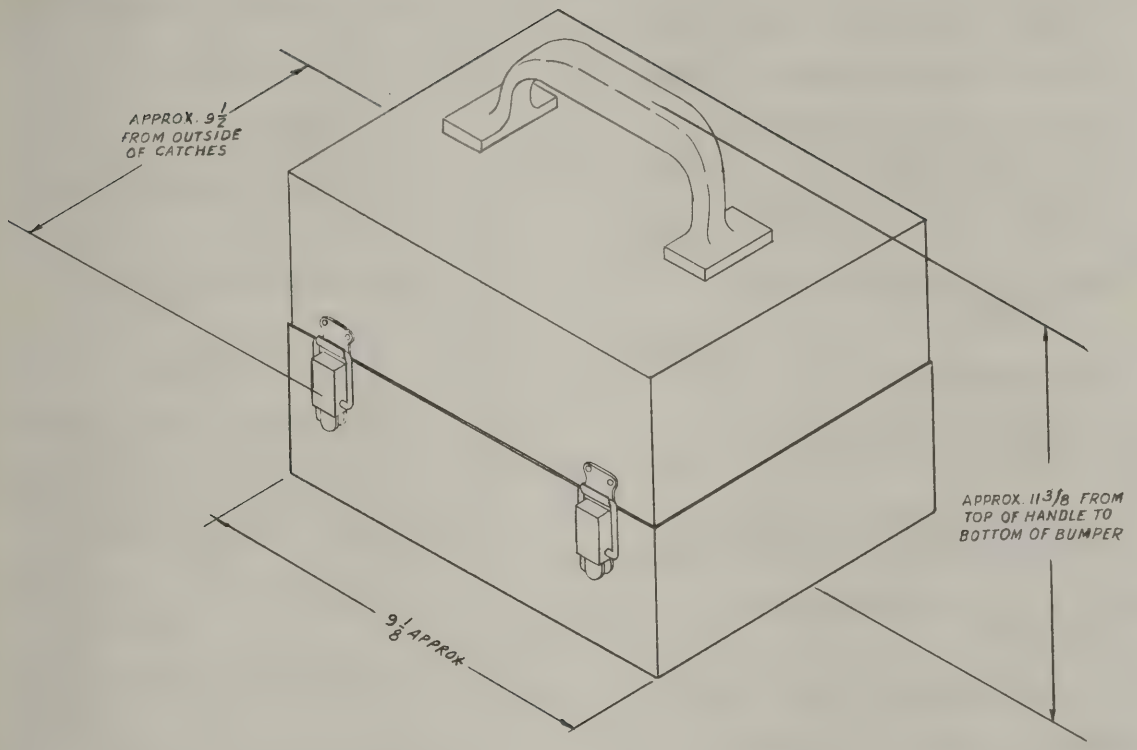


Figure 7-6. Radar Test Equipment Model TS-295/UP Outline Dimension

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date				
1. Meter Reading (R-F disconnected)	mw					
2. Meter Reading (R-F connected)	mw					
3. Average R-F Power (Item 1—Item 2)	mw					
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm					
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db					
6. 3-db Cable Loss (if used, no correction)	db					
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db					
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db					
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm					
10. Rated average power output of transmitter	dbm					
11. Measured average power (Item 9)	dbm					
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.)	db					

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm					
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db					
15. Peak Power (Item 13 + Item 14)	dbm					
16. Convert Item 15 to kw (See Fig. 4–1)	kw					

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date					
1. Meter Reading (R-F disconnected)	mw						
2. Meter Reading (R-F connected)	mw						
3. Average R-F Power (Item 1—Item 2)	mw						
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm						
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db						
6. 3-db Cable Loss (if used, no correction)	db						
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db						
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db						
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm						
10. Rated average power output of transmitter	dbm						
11. Measured average power (Item 9)	dbm						
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.)	db						

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm						
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db						
15. Peak Power (Item 13 + Item 14)	dbm						
16. Convert Item 15 to kw (See Fig. 4–1)	kw						

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date				
1. Meter Reading (R-F disconnected)	mw					
2. Meter Reading (R-F connected)	mw					
3. Average R-F Power (Item 1—Item 2)	mw					
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm					
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db					
6. 3-db Cable Loss (if used, no correction)	db					
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db					
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db					
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm					
10. Rated average power output of transmitter	dbm					
11. Measured average power (Item 9)	dbm					
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.)	db					

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm					
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db					
15. Peak Power (Item 13 + Item 14)	dbm					
16. Convert Item 15 to kw (See Fig. 4–1)	kw					

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date					
1. Meter Reading (R-F disconnected)	mw						
2. Meter Reading (R-F connected)	mw						
3. Average R-F Power (Item 1—Item 2)	mw						
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm						
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db						
6. 3-db Cable Loss (if used, no correction)	db						
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db						
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db						
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm						
10. Rated average power output of transmitter	dbm						
11. Measured average power (Item 9)	dbm						
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.)	db						

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm					
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db					
15. Peak Power (Item 13 + Item 14)	dbm					
16. Convert Item 15 to kw (See Fig. 4–1)	kw					

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date					
1. Meter Reading (R-F disconnected)	mw						
2. Meter Reading (R-F connected)	mw						
3. Average R-F Power (Item 1—Item 2)	mw						
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm						
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2)	db						
6. 3-db Cable Loss (if used, no correction)	db						
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db						
8. Radar Main Transmission Line Loss (0.02 db per ft.)	db						
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm						
10. Rated average power output of transmitter	dbm						
11. Measured average power (Item 9)	dbm						
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.)	db						

CALCULATION OF PEAK POWER

13. Average Power (Item 9)	dbm					
14. Duty Cycle (From Radar Book or from Fig. 4–3)	db					
15. Peak Power (Item 13 + Item 14)	dbm					
16. Convert Item 15 to kw (See Fig. 4–1)	kw					

RECORD OF TRANSMITTER POWER MEASUREMENTS

*Serial number of radar being measured.*_____

MEASUREMENT AND CALCULATION OF AVERAGE POWER

	Date	_____	_____	_____	_____	_____
1. Meter Reading (R-F disconnected)	mw	_____	_____	_____	_____	_____
2. Meter Reading (R-F connected)...	mw	_____	_____	_____	_____	_____
3. Average R-F Power (Item 1—Item 2)	mw	_____	_____	_____	_____	_____
4. Convert Item 3 to dbm (see Fig. 4–1)	dbm	_____	_____	_____	_____	_____
5. 10-db Cable Loss (Corrected for frequency, see Fig. 4–2).....	db	_____	_____	_____	_____	_____
6. 3-db Cable Loss (if used, no correction).....	db	_____	_____	_____	_____	_____
7. Directional coupler (loss stamped on coupler) or Antenna Space Loss	db	_____	_____	_____	_____	_____
8. Radar Main Transmission Line Loss (0.02 db per ft.).....	db	_____	_____	_____	_____	_____
9. Average Power Output of Transmitter (sum of Items 4 to 8 incl.)	dbm	_____	_____	_____	_____	_____
10. Rated average power output of transmitter.....	dbm	_____	_____	_____	_____	_____
11. Measured average power (Item 9)..	dbm	_____	_____	_____	_____	_____
12. Difference between measured and rated average power (Items 10 and 11. Record as − if measured power is the smaller, + if measured power is the greater.).....	db	_____	_____	_____	_____	_____

CALCULATION OF PEAK POWER

13. Average Power (Item 9).....	dbm	_____	_____	_____	_____	_____
14. Duty Cycle (From Radar Book or from Fig. 4–3).....	db	_____	_____	_____	_____	_____
15. Peak Power (Item 13 + Item 14)..	dbm	_____	_____	_____	_____	_____
16. Convert Item 15 to kw (See Fig. 4–1)	kw	_____	_____	_____	_____	_____

SECTION VIII
PARTS AND SPARE PARTS LISTS

TABLE 8-1

LIST OF MAJOR UNITS

QUANTITY	NAME OF MAJOR UNIT	NAVY TYPE DESIGNATION	SYMBOL GROUP
1	Radar Test Equipment TS-295/UP	TS-295/UP	101–199

TABLE 8-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION FOR NAVY TYPE TS-295/UP

PARTS									TOTAL NO. PER EQUIPMENT	SPARE PARTS EQUIP.		TEN-DER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED		BOX NO.	QUAN.	BOX NO.	QUAN.	BOX NO.	QUAN.
BAT 101	DRY CELL: 1.5 volts; diameter approximately 1 5/16", height approximately 2 3/8".	D-c power				BA-30 for Army CNC-19031 for Navy		BAT 101 BAT 102 BAT 103	3						
BAT 102	DRY CELL: same as BAT 101.	D-c power													
BAT 103	DRY CELL: same as BAT 101	D-c power													
M101	MILLIAMMETER: Self-contained, moving coil, permanent magnet type milliammeter housed in a 3½" flush type bakelite case; Current for full-scale deflection 1.5 milliamperes d-c; Resistance 75 ohms ± 1%; Accuracy 2% of full scale; ASA type designation is special.	Current indicator				W.E. Co. D-170136		M101	1		0		1		2

TABLE 8-2 (Cont'd)

PARTS									TOTAL NO. PER EQUIPMENT	SPARE PARTS EQUIP.		TEN-DER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED		BOX NO.	QUAN.	BOX NO.	QUAN.	BOX NO.	QUAN.
M102	FREQUENCY METER CAVITY & LOOP ASSEMBLY: A tunable resonant cavity into which projects a piston by means of a micrometer movement and counter dial indicator. Includes loop assembly. IN and OUT jacks per D-163476 and cabling RG-5/U. Also included are tabular and graphical calibration cards.	Measurement of frequency				W.E. Co.	B-435490	M102	1		0		1		2
R101	RESISTOR: Wire wound, tubular type, 100 ohms ± 1%, 1 watt.	Part of bridge circuit	–632565-1			I.R.C. WW3-2A Terminal	BA-10130-51	R101, R102, R103, R104	4		4		12		24
R102	RESISTOR: same as R101														
R103	RESISTOR: same as R101														
R104	RESISTOR: same as R101														
R105	RESISTOR: Wire wound, tubular type, 1000 ohms ± 1%, 1 watt.	Current limiting resistor in galvanometer circuit	–631269-1			I.R.C. WW3-2A Terminal		R105	1		1		3		6
R106	RESISTOR: Wire wound, tubular type, pigtail, 4.40 ohms ± 1%, 1 watt	Meter shunt	–632564-1			I.R.C. WW3-2A Terminal	BA-10130-50	R106	1		1		3		6
R108	POTENTIOMETER: (ADJUST CURRENT FINE), wire wound; 50 ohms ± 10%, 4 watts, over-all dimensions, body 0.98″ by 1⅞″ diameter; flatted shaft length ⅞″; distance from center line of shaft to outer end of soldering lugs 1.34″.	Fine current adjustment	RA30A1FD500AK			RA30A1FD500AK	JAN-R-19	R108	1		1		2		4

TABLE 8-2 (Cont'd)

PARTS									TOTAL NO. PER EQUIPMENT	SPARE PARTS EQUIP.		TEN-DER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED		BOX NO.	QUAN.	BOX NO.	QUAN.	BOX NO.	QUAN.
R109	POTENTIOMETER: (ADJUST CURRENT COARSE), wire wound, 1000 ohms ± 10%, 4 watts; over-all dimensions, body 0.98″ by 1⅞″ diameter; flatted shaft length ⅞″; distance from center line of shaft to outer end of soldering lugs 1.34″.	Coarse current adjustment	RA30A1FD102AK			RA30A1FD102AK	JAN-R-19	R109	1		1		2		4
R110	POTENTIOMETER: 100 ohms ± 10%, wire wound, 2 watts, linear taper, type 2 shaft ⅝″ long, ½″ bushing, hex. nut locking type.	Adjust meter shunt resistance	–632481-10			C.T.S. 252	BA-10034-559	R110	1		1		2		4
R113	THERMISTOR: Directly heated resistance bead contained in a glass bulb.	Compare RF and d-c power	–632568			W.E. Co. D-164699		R113	1		1		2		4
S101	KEY: (GALV SENS) Non-locking push button type key; special moisture-resistant 547 type key. Equipped with black button.	Galvanometer sensitivity control	–24444			W.E. Co. D-161894B	BA-105968	S101	1		1		1		1
S102	KEY: (TEST) Lever type; special moisture-resistant 501 type key equipped with a non-locking key unit which operates in one direction only. Black lever handle.	To transfer meter from use as a galvanometer to use as a milliammeter or power meter	–24443			W.E. Co. D-166856	BA-105947	S102	1		1		1		1
S103	TOGGLE SWITCH: (BAT) Double pole double throw; 3 amps.at 250 volts; 6 amps. at 125 volts.	Battery switch	–24235			H and H 81027-FA	ES-676800-14	S103	1		1		1		1
Y101	CRYSTAL: Silicon; cartridge type	Rectifier of RF	–1N21B –1N21 –1N21A –1N22			W.E. Co. 1N21B 1N21 1N21A 1N22		Y101	1		20		40	1	00

TABLE 8-2 (Cont'd)

PARTS									TOTAL NO. PER EQUIPMENT	SPARE PARTS EQUIP.		TENDER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED		BOX NO.	QUAN.	BOX NO.	QUAN.	BOX NO.	QUAN.
Z101	RADIO-FREQUENCY CHAMBER: 50 ohms special high-frequency chamber assembly.	Radio-frequency coaxial termination containing the thermistor				W.E. Co.	B-409719	Z101	1		0		1		2
Z102	CRYSTAL BLOCK ASSEMBLY: 50 ohm; ¾″ x ¾″ x 2¼″, for 1N21B crystal; crystal not furnished; includes termination assembly, jacks (CRYS IN) and (VIDEO) and crystal block.	Crystal mounting	-40158			W.E. Co.	B-435350	Z102	1		1		1		1
	CABLE ASSEMBLY: 10db connecting cable; modified RG-21/U coaxial cable wire; approximate length 11 ft.; each end has a (-49426) D-163472 plug.	Radio-frequency connecting cable	CG-258/U			W.E. Co.	B-435492		1		1		1		2
	CABLE ASSEMBLY: RG-9/U coaxial cable wire; length 60″ ± ½″; equipped with a (-49205) D-163469 plug on each end.	Radio-frequency connecting cable	CG-257/U			W.E. Co.	B-435493		1		1		1		2
	CABLE ASSEMBLY: RG-5/U coaxial cable wire; length 3½″ ± ¼″; equipped with a (-49426) D-163472 plug on each end.	Patch (FREQ METER OUT) jack to (MEAS PWR) jack	CG-256/U			W.E. Co.	B-435494		1		1		1		2
	CABLE ASSEMBLY: 3db ± ½ db connecting cable. Approx. length 3′ 4″.	Radio-frequency connecting cable	CG-358/U			W.E. Co.	BL-440294		1		1		1		2
	KEY: No. 8 short arm hex. key (Allen Wrench)	Wrench for No. 8 hex. socket set screw				Parker-K			1						
	KNOB: Fluted; arranged for ¼″ shaft and for 8-32 hex. socket set screw.	For COARSE and FINE potentiometers				Kurz-Kasch S-308-64BB-B	BA-10005-16		1						

TABLE 8-3

LIST OF PARTS BY NAVY NUMBERS

QUANTITY	NAVY TYPE NUMBER	ALL SYMBOL DESIGNATIONS INVOLVED
	SPECIAL RF DEVICES Class 14	
1		M102
1		Z101
	CRYSTALS Class A20	
1	–1N21B –1N21 –1N21A –1N22	Y101
	METERS Class 22	
1		M101
	SWITCHES Class 24	
1	–24444	S101
1	–24443	S102
1	–24235	S103

QUANTITY	NAVY TYPE NUMBER	ALL SYMBOL DESIGNATIONS INVOLVED
	PIEZOELECTRIC CRYSTAL AND HOLDERS Class 40	
1	–40158	Z102
	WIRES AND CONDUCTORS Class 62	
1	CG-256/U	No symbol—cable assembly
1	CG-257/U	No symbol—cable assembly
1	CG-258/U	No symbol—cable assembly
1	CG-358/U	No symbol—cable assembly
	RESISTORS AND POTENTIOMETERS Class 63	
4	–632565–1	R101, R102 R103, R104
1	–631269–1	R105
1	–632564–1	R106
1	RA30A1FD500AK	R108
1	RA30A1FD102AK	R109
1		R110
1	–632568	R113

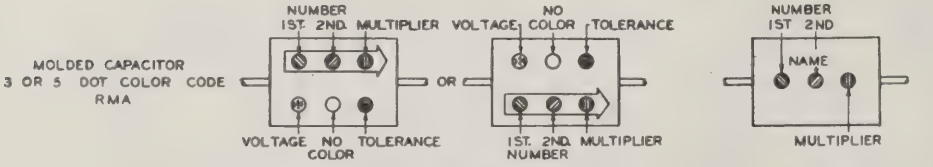
TABLE 8-4

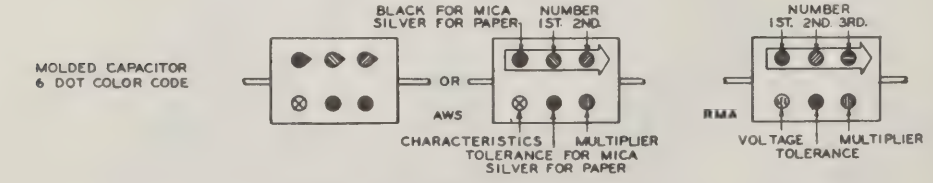
AWS AND RMA COLOR CODES
FOR CAPACITORS (MMF) AND RESISTORS (OHMS)

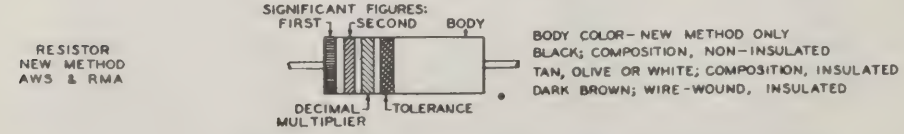
COLOR	NUMBER	MULTIPLIER[1]	TOLERANCE	VOLTS[2]	CHARACTERISTICS[3]
NO COLOR	–	–	±20%	300 OR 500	–
SILVER	–	.01	±10%	2000	–
GOLD	–	.1	±5%	1000	–
BLACK	0	1	±20%	–	A
BROWN	1	10	±1%	100	B
RED	2	100	±2%	200	C
ORANGE	3	1,000	±3%	300	D
YELLOW	4	10,000	±4%	400	E
GREEN	5	100,000	±5%	500	F
BLUE	6	1,000,000	±6%	600	G
VIOLET	7	10,000,000	±7%	700	–
GRAY	8	100,000,000	±8%	800	–
WHITE	9	1,000,000,000	±9%	900	–

NOTES: 1. MULTIPLIER GOES ONLY TO 1000 IN MOLDED CAPACITORS.
2. VOLTAGE RATING FOR CAPACITORS ONLY.
3. CHARACTERISTICS OF AWS CAPACITORS AS FOLLOWS:

	MICA	MOLDED PAPER
TYPE	TEMP COEFF. -PARTS/MILLION/C°	OPERATING TEMPERATURE RANGE
A. MICA-STACK, BY-PASS	–	-55° TO +85°C (-67° TO +185°F)
B. LIKE A, LOW LOSS CASE	–	-55° TO +75°C (-67° TO +167°F)
C. MICA-STACK OR SILVER-MICA	±200	–
D. SILVER-MICA	±100	–
E. SILVER-MICA	-20 TO +100	–
F. SILVER-MICA	0 TO + 70	–
G. SILVER-MICA	0 TO - 50	–







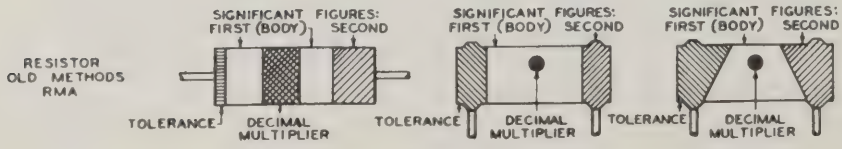


TABLE 8-5

LIST OF MANUFACTURERS

ABBREVIATION IN MFR'S. COLUMN OF TABLE OF REPLACEABLE PARTS	MFR'S. PREFIX	MANUFACTURER	ADDRESS
C.T.S.	C.T.C.	Chicago Telephone Supply	Elkhart, Indiana
H & H	C.H.H.	Arrow Hart & Hageman Electric Co.	342 Capitol Avenue, Hartford, Conn.
I.R.C.	C.I.R.	International Resistor Corp.	401 N. Broad Street, Philadelphia, Pa.
Kurz-Kasch		Kurz-Kasch, Inc.	Dayton, Ohio
Parker-K		Parker-Kalon Corp.	200 Varick Street, New York, N. Y.
W. E. Co.	C.W.	Western Electric Co.	195 Broadway, New York, N. Y.

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